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ANNUAL VOLUME OF TRANSACTIONS

The Thirty-Seventh Annual Volume of Transactions of The American Society of Mechanical Engineers will be issued this month.

The contents of the volume include:

Annual Report of the Council, giving a general review of the work of the Society for the year 1915.

Calendar of 90 meetings of the Society during the year 1915.

Papers and discussion presented at the Spring Meeting in Buffalo, N. Y., April, 1915.

Papers and discussion presented at the special general meeting in San Francisco, Cal., September, 1915, in connection with the Panama-Pacific International Engineering Exposition and the International Engineering Congress, 1915.

Papers and discussion presented at the Annual Meeting in New York, December, 1915.

Reports of Special Committees received by the Council during 1915 and ordered printed. These include the Power Test Report, and two Reports of the Committee on Standardization of Special Threads for Fixtures and Fittings.

Tributes to Frederick W. Taylor, an account of a Memorial Meeting held at the Annual Meeting, December, 1915.

The volume contains 1560 + xviii pages, 624 illustrations, 121 tables and a copious index. 6 in. x 9 in. *One copy, bound in half morocco, issued free to each standing member in 1915.* Price: bound in half morocco, $6.00 per volume to members, $11.00 per volume to non-members; bound in paper, $5.50 per volume to members, $10.00 to non-members.

Revises from individual papers and discussions included in this volume are also available in pamphlet form, and prices will be submitted upon application.

The Annual Meeting

New York, December Fifth to Eighth

ALL papers for the Annual Meeting should reach the Secretary not later than September 20. The Committee on Meetings cannot agree to consider papers received after this date.

The topics proposed for the all-day session on Valuation of Industrial Property were announced last month. The following are the tentative subjects of papers for the Gas Power Session:

Service Results with Heavy Oil Engines. Marine Diesel Engines. Experiences with Werkspoor Marine Diesel Engine. Gas Steam Engine at the Ford Plant. Tar Forming Temperatures of American Coals. American Experiences with the Humphrey Pump. Gas Tractors. Commercial Methods of Sampling and Analyzing Producer Gas.

There will also be sessions in charge of the Sub-Committees on Railroads and Machine Shop Practice, and contributions of one or more papers each from various other committees, besides the usual groups of miscellaneous papers representative of the most recent investigations in mechanical engineering throughout the country.

DYNAMIC BALANCE

An Elementary Explanation of the Phenomenon of Unbalance in Rotary Parts, and a Description of a New Machine with which Dynamic Balance can be Obtained Easily and Accurately

BY N. W. AKIMOFF,[1] PHILADELPHIA, PA.

IN this paper is described a machine devised by the author for correcting the condition of dynamic unbalance. The description is preceded by an explanation of the phenomenon of dynamic unbalance, made as elementary as possible by carefully excluding all references to products of inertia, momental ellipsoids, free and forced oscillations, etc. The subject of dynamic balance is not an involved one, and the author feels it is time it were placed on a purely rational basis.

For the general reader, a knowledge of the subject of dynamics of rotation as treated in Worthington's *Dynamics of Rotation* will suffice. To those who would like to develop a mathematical theory of the machine described, the author would recommend a study of Routh's *Dynamics*. Those interested in reciprocating balance are no doubt familiar with Dalby's well-known publication on the subject, and with Sharp's recent and extremely valuable *Balancing of Engines;* neither of these touches, however, in any way upon the subject of *dynamic balance* proper, in the sense in which it is generally understood and in which it will be considered in the present paper.

The balancing of reciprocating parts is purely a matter of calculations and of design; but the balancing of rotating parts, aside from the design, is a matter of trial and adjustment, because of its accidental nature.

In a theoretically perfect rotating body, symmetrical and made of homogeneous material, there cannot be any question of running balance,—such a condition would be understood as a matter of course. But we know that in practice nearly all bodies rotating at high speeds show a certain amount of unbalance. The immediate consequences of this unbalance are vibrations in automobiles and turbines; defective commutation in electrical machinery; undue wear and strain on bearings; defective products in the cases of grinding disks for steel balls, woodworking machinery, etc.

As is well known to all, an unbalanced condition of a rotating body may be due to two distinct causes: lack of static balance, and lack of dynamic balance.

By static balance is understood the condition when the center of mass of the body lies somewhere on the axis of rotation. Such a condition is easily obtained on one of the static balancing machines of the knife-edge or of the roller type. In order to place the body into static balance, it is sufficient to drill one hole or to add one weight, although either of these might be split up into one or more components whenever desirable, all of which does not present any special difficulties.

[1] Dynamic Balancing Machine Company, Philadelphia, Pa.

SYNOPSIS

An unbalanced condition of a body rotating at a relatively high speed, such as an armature, an automobile crankshaft, a ventilating fan, etc., may be due either to lack of static balance or lack of dynamic balance.

An indication of static unbalance may be obtained with a static balancing machine. Correcting for such unbalance involves drilling one hole or adding one weight to bring the center of the mass of the body on the axis of rotation.

In a statically balanced body, however, two masses on opposite sides of the axis of rotation, located axially at a distance from each other, form, on rotation, a couple which develops vibrations, as is noted in defective commutators in electrical machinery, etc. The machine described in the paper furnishes a means for determining easily and correctly the magnitude and plane of the couple.

The principle of the Akimoff machine is the establishing of another couple which, while maintaining the static balance, counteracts the couple which produces dynamic unbalance. The magnitude and plane of this couple indicates the correction to be applied to the body under test to produce perfect dynamic balance.

A rigid horizontal beam, such as a lathe bed, is hinged at one end and supported by a spring at the other. The body to be tested, already in perfect static balance, is rotatively supported on the beam. If dynamically unbalanced, the body will, on rotation, cause the beam to vibrate in a vertical plane. The object of the spring is to amplify the vibrations.

A so-called squirrel cage, disposed at the underside of the beam, is rotated in unison with the body being tested. This squirrel cage consists of two circular discs carrying an even number of rods arranged slidably in the two discs and parallel to the axis of rotation of the cages. When the ends of the rods are in one plane, the cage is in both static and dynamic balance, but if two opposite rods are displaced the dynamic balance is destroyed and the couple produced will itself cause vibration of the beam.

One pair of rods in the squirrel cage would suffice if the relative position of the rods could be altered through the transmission device, but for convenience three or four pairs are employed, and even then it is sometimes necessary to change the angular position of the cage so that the balancing can be done by one pair of rods and not two.

In making a test of a body the cage is adjusted so that the vibrations produced in the beam by the body are damped out by those set up by the squirrel cage. An arrangement whereby the rods of the cage may be adjusted axially while the cage is in rotation is provided and by utilizing this arrangement the rods are shifted until the desired effect is produced.

After the magnitude and plane of the unbalancing couple in the body under test is obtained, it is an easy matter to furnish directions for the workman to follow in removing the necessary material to secure dynamic balance. If a number of bodies of the same kind are to be tested the matter of giving instructions for correcting each piece is further simplified.

The paper was followed by an interesting discussion, which is here reproduced, with the author's closure. In the discussion the lag of unbalance in rotating bodies was considered, other forms of balancing machines in present use were described, and points of criticism of the author's machine were raised, to which he replied. The whole account forms an authoritative presentation of the principles and modern practice of balancing of rotating parts of machines.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 5 cents to members, 10 cents to non-members.

Now, by dynamic balance is understood the condition when there is no so-called ***centrifugal couple*** in any axial plane. In a statically balanced body, Fig. 1, a centrifugal couple can only be due to *two* masses, ***m*** and ***n***, on opposite sides of the shaft and located at a certain distance, *c*, axially, from each other. Such masses may be, for instance, the centers of gravity of corresponding congested regions. At any rate, in view of the static balance, (1) such masses must be in some axial plane, and (2) the products of each mass and its respective distance from the axis of rotation must be equal.

Such a couple is in general numerically equal to a certain coefficient multiplied by radius times weight times axial distance, that is, equal to *k.m.r.c.*, where *k* involves the speed as well as other numerical constants. Now we shall choose the unit of speed in such a manner that *k* can be made equal to

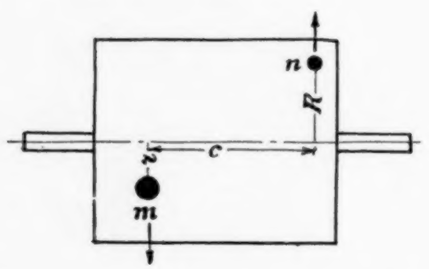

FIG. 1 CENTRIFUGAL COUPLE IN STATICALLY BALANCED BODY

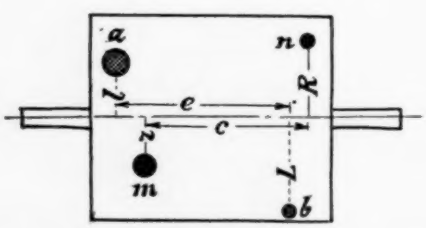

FIG. 3 COUPLE COUNTERACTING CENTRIFUGAL COUPLE

unity, so that the centrifugal couple is equal to ***m.r.c.*** or ***n.R.c.*** (since $mr = nR$).

Since the effect of a couple can only be counteracted by that of another couple, it will be seen that any effort to balance such a body as in Fig. 1 by adding *one* weight, or drilling *one* hole, cannot fail to make matters worse. Such a method not only does not take care of the centrifugal couple, but also distorts the static balance.

It seems to be a "natural feeling" that the way to correct unbalance is to drill a hole at the "high spot,"—the point where the marking tool touches the body. Indeed, it appears that various devices have been designed and are now on the market precisely for marking such "high spots," after which judicious removal of metal is supposed to secure the desired condition of balance. These devices are based upon the so-called floating bearing principle, Fig. 2, that is, are provided with bearings yielding in the horizontal plane to emphasize the running of the body out of true. Of course, all such devices can only serve to indicate that the body is out of balance; they can give neither the true axial plane of the disturbing centrifugal couple, nor the numerical value of it. Also, drilling in any one place, as has just been seen, cannot secure dynamic balance, but can only distort the static balance.

It appears likewise that an attempt has been made to balance round disks, wheels, pulleys, etc., by pivoting them on one point and by marking the "high side." It is extremely difficult to ascertain just what is the underlying idea of such apparatus, as rotation of bodies on a fixed axis and rotation about a fixed point are two entirely separate chapters of dynamics, the latter much more difficult than the former, and the deductions of one apply in no way to the other. The same remark applies to the method consisting of rotating a body suspended on a flexible shaft (wire rope) and observing the high spots in this manner. All such attempts to ascertain the dynamic unbalance are perfectly irrational.

What it is absolutely necessary to know, in a statically balanced body, is:

a the exact location of the axial plane of the disturbing centrifugal couple
b the exact numerical value of the disturbing couple
c the sign of the couple, i.e., the direction of the vector representing the couple.

Indeed, with the axial plane of the disturbing couple known, attention can be limited to that plane; and what is done on one side of the shaft will be repeated on the other side so

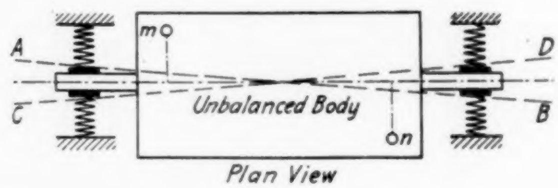

FIG. 2 FLOATING BEARING PRINCIPLE

as to preserve the static balance. Furthermore, with the numerical value of the couple ***m.r.c*** (Fig. 3) known, all that has to be done to secure dynamic balance is to introduce an opposing couple, ***a.l.e.***, of the same magnitude. Of course, this counteracting couple can be introduced in a variety of ways, small holes drilled on a large radius and far apart axially being equivalent to larger holes located on smaller radii and nearer to each other axially.

It will be seen from the above that a machine to deserve the name of dynamic balancing machine absolutely must indicate the plane of unbalance, as well as the numerical value and sign of the unbalancing couple. The author claims to have produced such a machine, of which the following is a brief description.

A rigid horizontal beam, such as a lathe bed, Fig. 4, is hinged at one end and supported by a spring at the other. The body to be tested, already in perfect static balance, is rotatively supported on the beam.

If dynamically unbalanced, the body will, when rotated, cause the beam to vibrate in a vertical plane, with a period of oscillation equal to the period of rotation of the body. In other words, if the speed of the unbalanced body is, say, 315 r.p.m., the beam will vibrate at the rate of 315 complete oscillations per minute, quite regardless of the characteristics of the spring (except possibly at the very beginning of the motion).

Now imagine a second body, exactly similar in every respect to the first, also in perfect static balance but dynam-

ically unbalanced to precisely the same extent as the first body, temporarily associated with the same beam, say suspended under it.

If these two bodies are oppositely located as to balance and run precisely at the same speed (synchronously), then the unbalancing or disturbing couples will cancel out, and the beam will have no tendency to vibrate, no matter how badly unbalanced, individually, are the two bodies. This is the fundamental principle of the machine,—to determine unbalance by determining the unbalance necessary to neutralize its effect.

In the actual machine, instead of the second body being an exact image of the original unbalanced body, it is a so-called squirrel cage, and this is rotated in unison with the article to be tested. The cage, Fig. 5, consists of two or more circular disks, carrying an even number of rods (usually six or eight) arranged slidably in the disks. The rods are accurately made

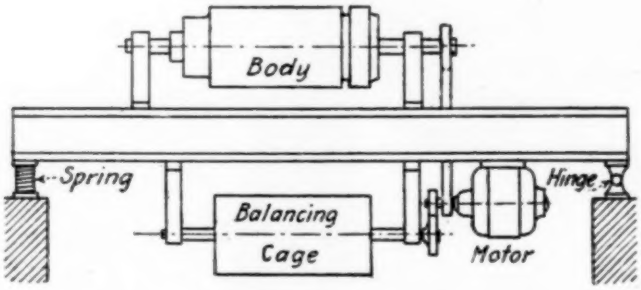

Fig. 4 Principle of Dynamic Balancing Machine

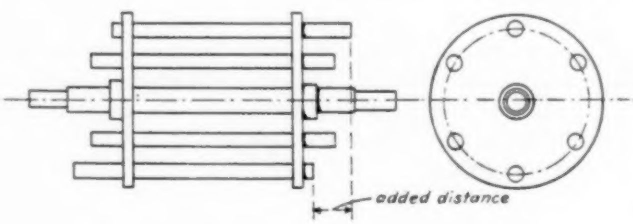

Fig. 5 Construction of Squirrel Cage

and their common weight is known; therefore, any displacement of one of the rods with respect to the one exactly opposite will not affect the static balance, originally perfect, of the cage, but will introduce a certain centrifugal couple, according to the relative displacement or *added distance*.

For instance, suppose that the unbalanced body is a special fan, Fig. 6, and that the unbalance is due to two excess weights, grossly exaggerated in the figure. This will result in a centrifugal couple, and to counteract it, the cage will have to be put into a state of dynamic unbalance, as shown by the relative displacement of the rods and as measured by the added distance.

Thus the cage has means for indicating the exact amount of unbalance which has been put into it in order to reproduce with the opposite sign the exact unbalance of the article being tested. For instance, the displacement or added distance of 15/16 in. may represent (for a certain speed) a couple of, say, 129 oz-in. The plane of unbalance is easily established by the location of the two rods, the moving of which into a new position stops the vibrations; and the value of the couple is immediately given by the added distance.

It should be clearly understood that the centrifugal couple due to the body acts upon the beam in a simple harmonic manner, that is, according to the law of sines; but so does the effect of the balancing cage. In other words, when the axial plane of unbalance is vertical, the effect of unbalance on the hinged beam is the greatest, as also is the effect of the correcting element, the cage.

When the plane of unbalance is horizontal, and to this is proportional the free period of the small oscillation of the beam, that of the correcting element is likewise horizontal, since the cage and the body rotate in unison, and neither is in any manner felt by the beam, which does not respond visibly to any but vertical efforts or the vertical components of other couples.

So far as the spring (Fig. 4) is concerned, its object is to intensify the amplitude of the vibrations, although an unbalanced body will always cause the whole bed to vibrate with a frequency corresponding to the speed of the body (on this principle is based the well-known vibrating tachometer).

However, there is an additional advantage in the use of the spring, as it is always possible to select the characteristics

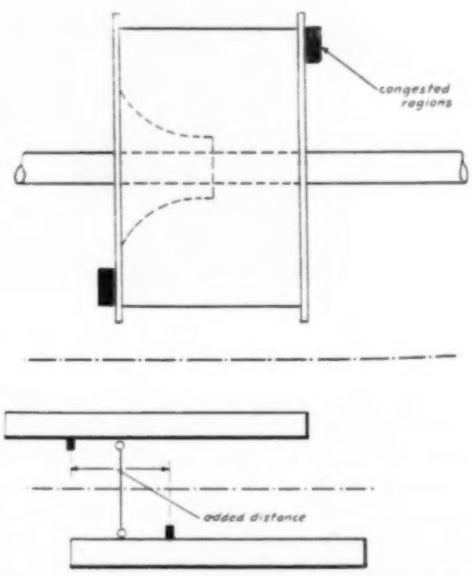

Fig. 6 Dynamic Unbalance in Special Fan

of this so that, under its load, its free period of oscillation will correspond exactly to the rate at which it is desired to run the test. Such a synchronism has a large magnifying effect, so that even a slight unbalance results in a considerable amplitude of oscillation. The natural period of oscillation of the spring is calculated from

$$T = 2\pi\sqrt{M U_d}$$

where

T = period in sec. of one complete (double) oscillation
M = mass by which spring is actually loaded
U_d = unit deflection, ft. per lb. load
π = 3.1416.

The details of construction of the cage would not be of any material interest in the present discussion, but the main feature is that the rods can be adjusted axially while the cage is in rotation, the speed of the cage never being higher than 400 r.p.m. or so.

With regard to the proper speed at which to balance a body, the author submits the following considerations: Unless the body itself is elastic or is mounted on a flimsy shaft, the body balanced at any speed will run true at any other speed. If the shaft is not strong enough, no balancing machine can

make it stronger. If the windings of a rotor seek to find their places under a certain speed and temperature, they should be allowed to do so, after which balancing can be done. In the "high spot" method, in which azimuth (commonly known as lag or lead) depends upon the speed itself, it is of course of considerable importance to watch the speed; but in the rational method here proposed the best speed is determined only by the characteristics of the spring, Fig. 4.

Fig. 7 illustrates a dynamic balancing machine arranged for testing armatures weighing up to 2000 lb., previously placed in perfect static balance. The information furnished by the machine is simply the relative displacement (added distance) of one of the pairs of rods of the squirrel cage.

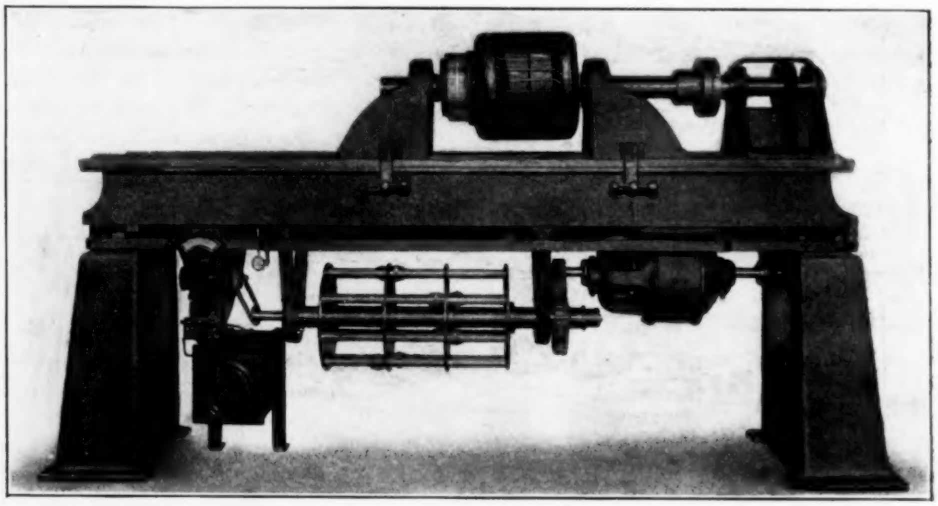

FIG. 7 DYNAMIC BALANCING MACHINE, TESTING ARMATURE

The paper also shows the machine arranged for testing automobile crankshafts, in which case, by referring to a set of specially prepared tables, similar to the one shown in Fig. 8, the operator can pick out readily the necessary directions as to how to remove a certain amount of metal from one of the cranks, and how to drill the flange in order to secure perfect dynamic balance.

An application of the machine for testing special blowers is also shown. If all such fans are of the same size, the directions in this case are also given in a very easy form.

CONCLUSION

It is not necessary to dwell on the extreme importance of testing a body for unbalance in its natural position and upon its own bearings. This machine, in its very conception, is adapted for testing under such conditions. The shaft in Fig. 8 has been tested in its own crank case.

The importance of static balance cannot be overestimated. Fortunately such a condition can be readily secured.

Theoretically, one pair of rods in the squirrel cage, Fig. 5, of the machine would suffice, since the relative position of the rods to the body being tested can be altered readily through the transmission (chain drive shown in Fig. 4). For convenience, however, it is best to have three or four pairs of rods, and even then it is sometimes necessary to change the angular position of the cage so that the balancing can be done by one pair of rods, and not two, as often happens at the beginning of a test.

DISCUSSION

MR. HALSEY DISCUSSES THE LAG OF UNBALANCE OF REVOLVING BODIES

F. A. HALSEY (written). For some years students and practitioners of the art of balancing have known that the high spot of a revolving unbalanced body is not truly radial with the heavy spot, but that it lags behind it by an indeterminate angle when the heavy spot is high, as it runs ahead of the light spot when it is high. This has been attributed to various causes—friction and inertia especially—though it has not been shown how these causes could produce this effect. Along with this go two other unexplained phenomena—the reversal of the body from the position in which the heavy spot is high to that in which the light spot is high and the failure of the shaft to break with indefinite increase of speed as previous analysis indicates that it should do.

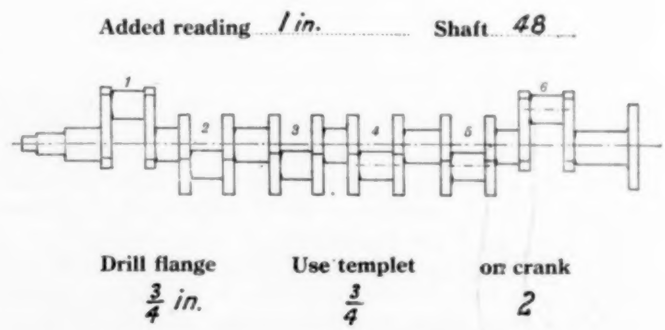

FIG. 8 DIRECTIONS FOR BALANCING SHAFT

It is the object of this discussion to explain the lag and to at least indicate an explanation of the other phenomena.

Fig. 9*a* represents two balls of the same diameter but of unequal weights (the heavier ball being indicated by the heavier shading) mounted on a light cross arm and a flexible shaft running in constrained bearings. The center of figure C_f is also the center of rotation, the center of gravity being at C_g. If the system be set in revolution the centrifugal force of the heavier ball will exceed that of the lighter, the result being the springing of the shaft as indicated in Fig. *b*, the heavier ball

being high and the centers of figure and of rotation taking the positions C_f and C_r. This statement is, however, true in a general sense only. Observation shows that the highest spot lags behind the heavy side by an angle which increases with the speed. To the best of my knowledge this is a recent discovery.[1] Observation further shows that at sufficiently high speeds (that is, above the critical speed) the action is reversed, the light side running high in constrained rotation at such speeds, as it does in free rotation at all speeds, while the lag, measured from the light high side, becomes a lead.[2] This action has long been known, as have the conditions under which it is possible, but I am not aware of any satisfying explanation of the reason for the reversal by which the heavy side, which is high at low speeds, becomes low at high speeds. The two flexure to invert itself to the condition of Fig. *c* at the critical, or any other, speed. While, then, we are now in position to understand why the light side should continue to run high, provided it were once placed in that position when running at a sufficiently high speed, we have found no explanation of the manner in which it gets into that position nor have we found any forces at work tending to place it there.

The reversal is due to the lag and it takes place when the lag equals 90 deg. The cause of the lag must, therefore, first be explained. It is due to resistance to rotation which is felt by all rotating parts of actual mechanism—that being what they are for. There are two fundamentally different conditions to be noted, first that of a body driven from the center and experiencing resistance at the periphery, as the armature of

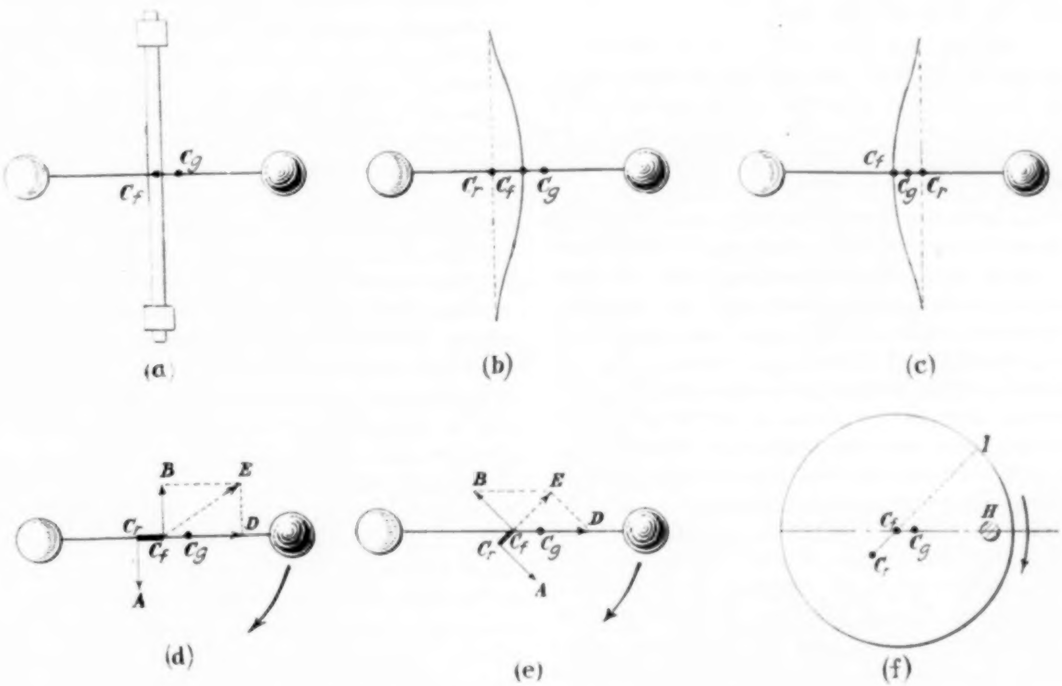

Fig. 9 Lag of Unbalance of Revolving Bodies

phenomena—lag and reversal—are apparently connected, the former as the cause of the latter.

Before explaining the phenomena—so far as they can be explained—it is necessary to show the conditions under which a constrained body may rotate with its light side high.

Assuming the shaft to be sufficiently flexible and the speed sufficiently high, it is clear that, could the system be placed in the position of Fig. *c*, the centrifugal force and the elastic resistance of the shaft would be exerted in opposite directions and hence would balance, the light side being the high side. What, however, is the explanation of the change of position? Why should a body rotating under the conditions of Fig. *b* change itself to the conditions of Fig. *c*?

Contemplation of Fig. *b* would lead one to expect the opposite tendency, for the higher the speed, the greater the centrifugal force and the more the shaft should deflect in the direction of Fig. *b*, with no discoverable tendency for the direction of

[1] The first publication of it to come under my eye was in an article by E. R. Douglass, published in the "American Machinist" for Feb. 22, 1906. It is interesting to know that it was this article that directed the attention of C. H. Norton to the subject and ultimately led to the design of his balancing machine.

[2] The action, as is well known, is utilized in the De Laval steam turbine in which, by the use of a flexible shaft, the critical speed is brought below the operating speed of the turbine.

an electric generator, and second a body driven at the periphery and experiencing resistance at the center, as the armature of an electric motor.

Consider the system of Fig. *b*, redrawing it in plan as in Fig. *d*, and consider the effect of the resistance of the air, which is always present, even if we have no other.

The centers of rotation, of figure and of gravity, are indicated as before by the letters C_r, C_f and C_g, while the arm of the elongated crank, due to the spring of the shaft, is shown by the heavy line from C_r to C_f. The direction of rotation being that of the arrow, the resistance of the air exerts a reacting couple, one component of which, C_rA, exerts a pressure on the bearings and may be neglected, while the other, C_fB, exerts a tangential pressure on the crankpin. The centrifugal force C_fD, is exerted as shown, the resultant of the tangential pressure and the centrifugal force being C_fE. Now the deflection of the shaft which forms the elongated crank is due to the applied forces and the direction of the crank must be that of the resultant C_fE. Redrawing Fig. *d* to show this condition, remembering that the reacting force due to air resistance is tangential, we get Fig. *e*, the direction of the crank being plainly at an angle with the line connecting the balls. The highest spot being radially an extension of the crank, we have

at once a satisfactory explanation of the lag. This is, perhaps, plainer from Fig. *f*, in which a disk with a heavy spot at *H* is substituted for the pair of balls. Plainly, the highest spot is at *I* radial with the crank and lagging behind the heavy spot.

Fig. *e* requires, however, another correction to make it strictly accurate. With the crank at an angle with the connecting bar, the centrifugal force will no longer act lengthwise of the bar, but on a radius through C_r and C_g. This changes the form of the parallelogram of forces, but it does not alter the tendency of the air resistance to produce the lag.

Experiment shows the lag to increase with the speed (because, in a balancing machine, the air resistance increases with the speed) and the speed at which the angle of lag equals 90 deg. is the critical speed at which the change takes place, and at higher speeds the light side runs high.

To put it in another way, instead of a simple progressive increase of the centrifugal force with increase of speed, as has been assumed, there is also a progressive change of direction of the resultant which ultimately puts the body over to the position in which the light side is high and before the force becomes so great as to break the shaft.

Proof that the lag is due primarily to the tangential force and not to speed is found in the experience of the General Electric Co., which finds, when balancing rotors of steam turbines, that, the speed remaining unchanged, the lag differs with the direction of rotation. With most bodies the air resistance is the same for both directions of rotation, the only method of changing the resistance being by changing the speed. In steam turbines, however, the shape of the buckets causes the resistance to change with the direction of rotation, and, with this condition introduced, we find the lag to change without change of speed but with change of force.

In a steam turbine or an electric motor, the forces C_rA and C_tB, sketched in Figs. *d* and *e*, are reversed, the impulse being applied at the periphery while the resistance due to the load is applied at the shaft. In such machines, therefore, it would appear that the high side should *lead* the heavy spot instead of lagging behind it. I am not aware that observations have been made to cover this point or, indeed, that the inference has before been pointed out, but the observations deserve making. In the balancing machine, to which our observations have been limited, the body under test is always driven from the center, the opposite condition having escaped observation.

While the action described is clear, the analysis, nevertheless, is incomplete. It is obvious that the turning force must be adequate to produce the result, and it is also obvious that the speed and the flexibility of the shaft must concurrently be such as to make the maintenance of the reversed condition possible. Moreover, linked with the flexibility of the shaft and the speed, is the eccentricity of the center of gravity. It will be apparent from a moment's consideration of Fig. *c*, that the greater the distance between C_t and C_g, the higher will be the speed at which, with a given flexibility of shaft, the conditions of the illustration can be maintained. I am not aware of any analysis covering these points, nor have I been able to carry one to a conclusion. The nature of the forces involved would lead one to expect more fruitful results from experimental than from analytical investigation.

It is, however, necessary to assume that the condition of Fig. *c* is more stable than that of Fig. *b*. Were it otherwise a force sufficient to produce the change from Fig. *b* to Fig. *c* would also produce a change back again, resulting in repeated alternation between the two positions, which does not, in fact, take place. There would thus seem to be no doubt of the superior stability of Fig. *c*, although I am not aware of any explanation of the fact.

MR. LORING BELIEVES BALANCE CAN BE OBTAINED IN THREE SHOTS. CRITICIZES SPEED OF BALANCE

E. J. LORING (written). I would define a body as dynamically balanced when its unconstrained axis of rotation is concentric with its journals.

The method proposed assumes perfect static balance, but dynamic balance conditions are far more sensitive because a slight static unbalance is greatly magnified at high speed. I do not agree that static balance is easily obtained. On the contrary unbalance always persists to some degree and must be provided for in the dynamic balancing operation. A body dynamically unbalanced does not usually show high spots diametrically opposite at the two ends, as it would if a simple couple were acting.

The wire rope suspension is not irrational. It supports the shaft with far less constraint than any rigid bearing, transforms a "rigid shaft" construction to "flexible shaft" conditions, and leaves the rotating body more nearly free to rotate on its own principal axis in space.

When provision is made for attaching balancing weights in two well-separated planes between the bearings of a two-bearing shaft, it is possible to determine the position and amount of added weight required in the nearer plane to each bearing in not more than three "shots," and with this information for each balancing plane the proper weight and position for each plane to clear both bearings simultaneously may be found by a simple calculation.

A slow-speed test is by no means conclusive; a body in dynamic balance at 400 r.p.m. may be dangerously far from balance at 3000 r.p.m. When corrected for 400 r.p.m. it is safer than when only statically balanced, but its balance is never fully proven at less than its full speed.

I would be interested to know how the correct plane of displaced rods is picked out from the behavior of the beam and the rotating body. Is it by a definite rule or by selection and trial?

MR. HODGKINSON SEES OBJECTION TO AKIMOFF MACHINE IN NECESSITY FOR STATIC BALANCE FIRST

F. HODGKINSON (written). It seems to me that the author's device is open to the objection that the member to be dynamically balanced must be put in perfect static balance before being balanced by the means described. In the case of heavy revolving bodies this is quite difficult, and is not to be satisfactorily attained by the usual method of rolling the body on ways or the like. Therefore, it seems to me that a machine for dynamic balancing should also render possible the elimination of errors in static balance.

Mr. Akimoff points out that he is enabled to move the rods of his balancing machine axially while the cage is in rotation, but withholds his method for accomplishing this and the details of the cage.

It would seem evident that the spring support at one end of his frame should have a natural period of oscillation equal to the period of revolution of the body being balanced. This of course would mean a different spring for every different weight of body applied, which would require some calculation in advance of doing the work, where there is a great variety of things to be balanced.

The author speaks disparagingly of the older method of securing dynamic balance, that is, running the body at a reasonably high speed and marking the shaft and determining the "high spots." He says they can only serve to indicate the body is out of balance. As a matter of fact, a very well organized system of adding weights may be employed which renders both the static and dynamic balancing of the body a simple operation. One of the hardships of the matter, however, is that the adding of weights or drilling, as the case may be, must be done more or less piecemeal, and the time occupied by speeding up and shutting down occasions a rather severe loss.

In stating that the static balance is not easily obtained, I referred particularly to bodies such as revolving fields of great weight where to mount these on ways, giving them a rolling balance, is unsatisfactory because, in spite of the surfaces being hardened and made as level as possible, the journals will sink into the ways to a slight degree, so extreme sensitiveness cannot be obtained because of the field having to run up hill.

It has been frequently found, in the case of very large fields, that an approximate static balance may be obtained by smearing the bearing surface and journals well with a heavy cylinder oil, dropping the field into the bearings and quickly removing the chains, that the friction would be so low that the field would respond to an error in static balance better than the previously described method of rolling on ways. Of course the field must not be allowed to stand more than a fraction of a minute, or until the oil film has been squeezed out, for then of course the friction becomes very material.

So far as steam turbines are concerned, it has not been the practice of the company with which I am associated to resort to dynamic balancing except in a few extreme cases. Turbines generally are comprised of a drum or quill to which are attached the spindle ends and journals. This drum has secured to it a certain number of disks or rings. Generally the speed of the drum is low, so that ordinarily static balancing, that is rolling on ways, is sufficient. Further, the disks or rings are short in their axial length as compared with their diameters, and a careful static balancing of these is found to be all sufficient. For balancing these disks and rings, a special static balancing machine was devised many years ago and has been in continual use. Inasmuch as this paper is confined to the subject of "dynamic balancing" its description is out of place. To those interested, a fair description of it is found in U. S. Patent No. 710,148, September 30, 1902. I might further add that with this machine a disk weighing 4000 or 5000 lb. may be given a static balance within an error of half an ounce.

SYSTEM EMPLOYED BY WESTINGHOUSE COMPANIES

I stated previously that there is an organized system available for balancing bodies which Mr. Akimoff disparages, and which he has illustrated in Fig. 2. It may perhaps be of interest to describe this system, although the description is rather more of instruction to a mechanic than technical data for the records of the Society.

The bearings being mounted on springs as described is not really a necessity. The bearings employed for large turbine rotors have enough clearance and oil film thickness to give sufficient amplitude of vibration to determine the "high spots," although in building a balancing machine, I would prefer to mount the bearings on springs, or their equivalent, but taking care that the natural period of oscillation of the bearings and the rotary masses be higher than that of the running speed to be employed in balancing. It does not matter at what speed the balancing is done, any more than it would with the machine Mr. Akimoff describes. It is only necessary to run it fast enough so that the vibration due to error in the balancing is well in evidence. It is necessary, however, that marks be applied to the shaft always at the same speed, because the angle between the error in the balance and the mark on the shaft will vary with different speeds. It is invariably found that the error in balance will be a number of angular degrees behind the mark, this angle becoming less with the speed, and greater with more rigid shafts. Inasmuch as it is the centrifugal couple which is to be eliminated and the bodies are of such proportions, that is, great relative axial length, and the balancing at each end must be done independently and as in the case of Mr. Akimoff's machine, it is impossible to eliminate centrifugal couples such as he illustrates. It is found in practice that it is undesirable to work on more than one end at a time, and the end should be first selected which is most out of balance, this to be judged by the degree of eccentricity of the path of the shaft rather than the shaking of pedestals, bedplates, and such. Having marked the shaft at each end, a mark is made which may be used for future reference, and a temporary weight is added, as judgment would dictate, some degrees behind the mark. On the machine again being speeded up, it may be found that the balance may be better, but the position of the mark has changed. If this is so, an additional weight should be added, or the original weight have its angular position moved so as to maintain the mark in its original position, continuing the operation, one end or the other, whichever has the most eccentric path. This process is carried on, and if the mark is maintained in the original position, it will be found finally that a weight added will throw this mark 180 deg. away from its original position, when the weights are then slightly in excess of that required for perfect balance, and only require to be slightly reduced.

By such means both error in static balance and in centrifugal couple are simultaneously eliminated. Balancing frequently has to be performed in the field—when it is successfully carried out in its own bearings and with no knowledge as to the condition of static balance. Plainly, should the marks appear at each end on opposite sides of the shaft, and the body run with similar eccentricity at each end, it would be inferred that the body was in static balance, only requiring the correction of the centrifugal couple.

Generally speaking, it is the practice of the Westinghouse companies to employ this method for all larger revolving fields, as well as for the occasional times when a turbine rotor may need dynamic balancing because some element of it is, due to some error, out of static balance. For small generator rotors, a Norton balancing machine is successfully employed and an addition to the companies' balancing equipment is about to be made of one of the machines the author describes.

MR. FAIRFIELD DESCRIBES THE NORTON BALANCE INDICATING MACHINE

Howard P. Fairfield (written). The necessity for providing some means for indicating a running balance was perhaps first realized a generation or two ago when woodworking machines having rotating cutter heads, and threshing machines for grain, were placed on the market. In the case of wood planing machines the cylinders upon which the knives or cutters were mounted were given a rotative speed, and in the case

of the threshing machines the teeth which beat the grain from the straw were attached to a cylindrical drum which was made to rotate at a considerable speed. The first attempt at solving this question with which I am familiar was by placing the piece to be tested in a pair of boxes that were hung from the ceiling by a wire. The part being tested was then rotated at speed, and its action noted and indicated by the operator, who made the necessary weight change to give the required effect.

One of the most extended investigations of the problem of balancing rotating bodies that has ever been conducted was carried on by Charles H. Norton, Mem.Am.Soc.M.E., who later developed his well-known Balance Indicating Machine, which indicates running balance only, no attention being given to questions of standing balance. It is believed this was the first machine to provide a means by which the workman could locate the position of the error of balance with any degree of

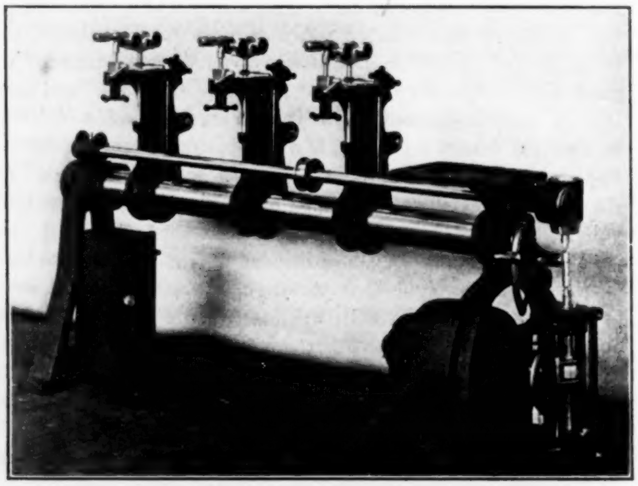

FIG. 10 NORTON BALANCE INDICATING MACHINE

accuracy, which he accomplished by providing means for reversing the direction of rotation, thus eliminating the guesswork in indicating due to the lag.

Mr. Norton's machine, as shown by Fig. 10, consists of a round steel supporting bar, which may vary in length as conditions warrant, supported by two floor stands. By means of a disk friction drive, connected with suitable gearing, an electric motor gives rotation to the smaller pulley-carrying shaft seen immediately above the supporting bar. The upper works consist of two or more upright frames carrying vertical pendulums. The pendulums are seated at their lower ends in suitable sockets, and on their upper ends are provided with a small table upon which are mounted light anti-friction rollers. Opposite the rollers are placed marking pointers. Connected with the vertical pendulums and fulcrumed to the sides of the uprights are the vibrators which indicate the unbalance of the rotating part. The piece to be indicated is mounted on rollers upon the top of the inverted pendulums.

If, when rotated at any speed, the piece being indicated is not in running balance, the vibrating indicators will show as they do in Fig. 11, where they indicate that the piece is out of running balance at each end. When the piece is in running balance, these indicators are perfectly still.

Unless the piece to be indicated is so slender as to spring appreciably, it makes no especial difference, of course, at what speed it is indicated; however, in practice, I believe it customary to indicate the work when it is being rotated above the so-called "critical speed."

Fig. 12 well shows diagrammatically the action of the vibrating indicator as the piece approaches, reaches and passes beyond the critical speed.

Fig. 13 shows a shaft that has been "marked" when rotated below the critical speed. Below this speed the indicated spots are behind the exact heavy spot, whatever the direction of rotation. Rotating the piece in two directions and locating arrow heads in the length center of the two marks indicates the exact heavy spot, as centered equidistant from the arrow points.

Fig. 14 shows a shaft rotated above the critical speed marked and arrowed as above, the arrow heads in each case flying in the direction of rotation.

In using this machine the following points have been noted: When the piece is rotated below the critical speed, the operator marks the heavier side, above the critical speed the lighter side. When marked on the heavier side, the marks lag or are behind the exact heavy spot when the direction of rotation for each mark is considered.

When marking on the lighter side, the marks lead the exact light spot. When marking on the heavier side, the arrows point toward each other. When marking on the lighter side,

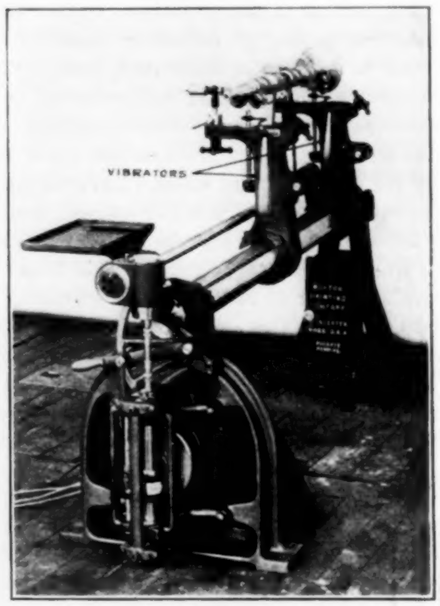

FIG. 11 NORTON MACHINE INDICATING RUNNING UNBALANCE

the arrows point away from each other. The true heavy spot lies midway between the points of the arrows.

In closing this description, it may be well to take note of several practical points that have been well proven in practice:

a That while a body placed in static balance may be decidedly out of running balance, one that is placed in running balance must also be in static balance

b Exact symmetry of form must not be taken to mean that the machine part is in running balance

c A machine part put in running balance at any speed is certainly in running balance at any other speed if it is not distorted from its true axial condition. This fact renders it possible, therefore, to rotate the part which is being tested at any speed desired which does not distort or spring it.

It will be admitted, I think, by all users of speed machinery that all rotating parts should be placed in exact running balance if the machine is to quietly perform its functions.

MR. HYMANS CONSIDERS AUTHOR HAS FOUND COMPLETE AND PRACTICAL SOLUTION OF PROBLEM

F. HYMANS (written). In addition to the detrimental effects of an unbalanced rotating body enumerated in this paper, loss of power in causing and maintaining vibrations of the structure supporting the body should be mentioned. This loss has been demonstrated by Sommerfeld (Z. d. V. d. Ing., 1902) in experiments with a small electric motor which carried on its shaft an eccentric weight. Placing the motor on a table, it was found that at 310 r.p.m. the table began to execute horizontal vibrations. In an endeavor to increase the motor speed the voltage impressed on the armature was raised. It was found, however, that the voltage could be considerably increased without causing any increase in the speed of the

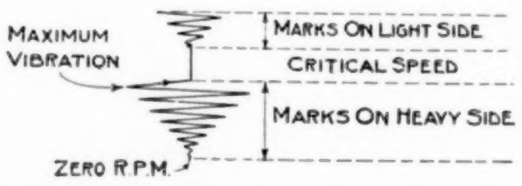

FIG. 12 ACTION OF VIBRATOR PASSING CRITICAL SPEED

motor and the increased power consumption was absorbed in maintaining the vibrations of the table.

By perfect balance of a body rotating freely around a horizontal axis is understood the condition when there is no bearing pressure, save that due to the body's weight. If it were possible therefore to measure directly the bearing pressure and its direction relative to the body, we should have the simplest form of a balancing machine and be in a position to determine the corrections necessary to bring about perfect balance. Unfortunately, however, direct measurement of forces is rarely possible.

It is not impossible to determine the corrective means for static as well as dynamic balance simultaneously on one and the same machine. However, the problem is considerably simplified if a static balance is first secured, as in a body so balanced the resultant of the centrifugal forces to which its particles are subject is a couple only, instead of a couple and a force, as in a body entirely unbalanced.

Considering more in particular the balancing machines of the vibrating type, we can broadly divide them in two classes, namely:

First, machines in which the vibrations excited by the centrifugal couple are directly employed to determine its plane of action, as is the case with nearly all balancing machines existing heretofore. (See also description of the Lavaczeck machine in The Journal, March, 1916.) *Second,* machines in which the vibrations are merely employed to indicate lack of balance, of which class Mr. Akimoff's machine is to date the sole example.

Referring to the first mentioned class, the position of the plane of unbalance is always determined by observing the position of the body at the instant of maximum amplitude of the oscillations. When the body is rotated at a sufficiently low speed, so that the period of rotation is very large as compared with the period of free vibration of the system, the oscillations of the machine will be in phase with the exciting forces, and it is a simple matter to determine accurately the plane and even the magnitude of the centrifugal couple. A machine so arranged would, however, not be sensitive enough for the purpose.

On the other hand when the body is rotated at a speed at which the period of free vibration of the system is no longer negligible as compared with the period of rotation, there is a phase difference, due to mechanical friction and damping forces, between exciting forces and oscillations. As the amount of this phase difference is uncertain, the plane of unbalance can only be determined approximately. In addition the oscillations can no longer be employed to calculate the magnitude of the centrifugal couple.

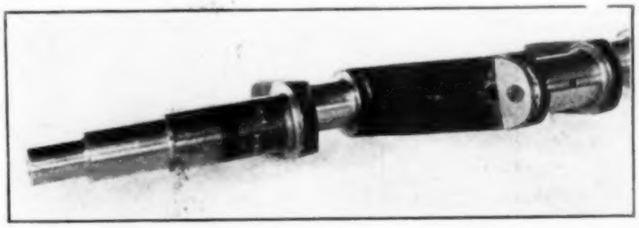

FIG. 13 PIECE MARKED ON NORTON MACHINE BELOW CRITICAL SPEED

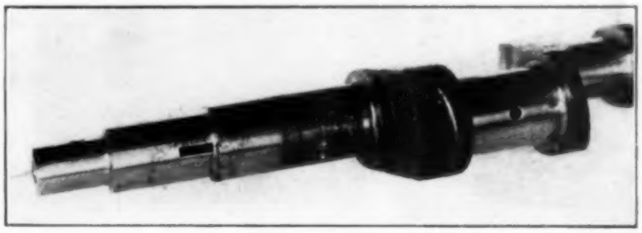

FIG. 14 PIECE MARKED ON NORTON MACHINE ABOVE CRITICAL SPEED

In the Akimoff machine it is quite immaterial if there is phase difference between oscillations and exciting forces. As described, an additional couple is introduced, which can be so adjusted in phase and magnitude, that the vibrations of the balancing machine vanish. The machine affords therefore at once the means to determine exactly both the plane and amount of unbalance. Disturbing influences such as "weakness" of the shaft of the rotating body can be practically wholly eliminated by selecting a spring of a flexibility which is large as compared with that of the shaft. In other words by the proper selection of the spring, the speed of rotation of the balancing machine can be made sufficiently low, that the transverse vibrations which the centrifugal couple tends to set up in the shaft of the rotating body will be practically of no effect on the beam of the balancing machine.

Looking at the matter from any angle, it must be conceded that Mr. Akimoff has found a complete and practical solution of the problem, and with the advent of a machine with which a perfect balance can be obtained easily and accurately, there should be no reason why a perfect balance should not become a standard requirement for nearly all classes of rotating machinery.

MR. RIDDELL COMPARES HORIZONTAL AND VERTICAL BALANCING MACHINES

JOHN RIDDELL (written). The use of balancing machines has now become universal, and the results are generally satisfactory, both as regards the quality of work produced as well as in the matter of economy. It becomes simply a matter of selecting the type of machine deemed most suitable for the particular kind of work to be done, and more particularly depending on the degree of perfection of balance desired.

It appears that present day balancing machines can be divided into two distinct classes: *First,* with vertical rotor suspended from an overhead drive by a cable or a flexible shaft. Such a machine is shown in Fig. 15. *Second,* with horizontal rotor running either in ordinary bearings or on rollers carried in suitable holders that can rock against springs or buffers of some description,—in other words, bearings that possess some degree of flexibility. A horizontal machine is shown in Fig. 16.

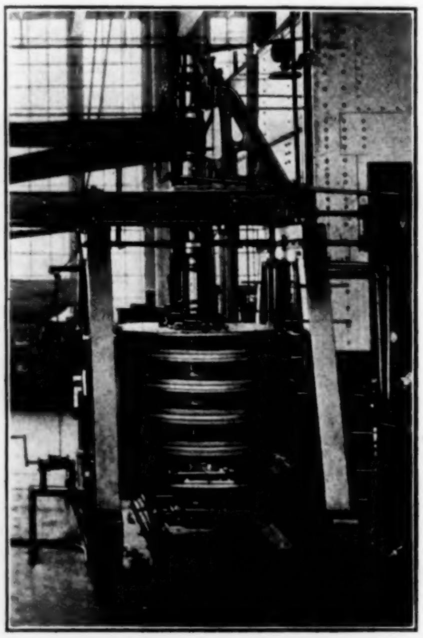

FIG. 15 TYPICAL VERTICAL BALANCING MACHINE

The writer's experience is that the vertical machine gives the most perfect balance, owing, no doubt, to the fact that there are no bearings to influence the running of the rotor, and also that the rotor, being suspended, can run out and show the amount "out" much more easily and to a greater degree than if supported in bearings.

The cost of balancing with the vertical machine is, at least for heavy work, somewhat greater than with the horizontal machine, partly on account of attaching the work to be balanced to the machine.

The vertical machine is so much more sensitive than the horizontal type that the very balancing operation becomes somewhat more delicate, and it is no doubt often the case that the refinement obtainable on a vertical machine is not needed for some kinds of work. In such cases, it is proper to use the horizontal machine. One thing should be remembered, however, and that is, that when it is desired to balance a rotor, the service speed of which is somewhere near its critical speed, it is much easier to do the balancing in the vertical than in the horizontal machine, owing to the fact that the rotor is suspended, and therefore not subject to bending during the operation.

It is the opinion of the writer that in order to give a body perfect dynamic balance, it is necessary to do this at a speed at least equal to the maximum speed at which it is to be operated in actual service, as it is quite possible to have an apparently perfect dynamic balance at one speed and then find that the balance shows imperfectly at higher speeds. Whereas, if a body is in perfect balance at its highest speed, it will also prove to be in perfect balance at all lower speeds.

I wish to say also that in my opinion it is a useless and wasteful practice, except in a very few specific cases, to give a body a static balance if a dynamic balance is to be finally produced.

MR. BRYSON RAISES SOME QUESTIONS REGARDING PRINCIPLES OF THE MACHINE

T. A. BRYSON[1] (written). The author explains that it is extremely difficult to ascertain the underlying idea of apparatus in which the axis of the body is pivoted at one point, and that the dynamics of the case is much more difficult of solution than that of a body having a fixed axis. Is not the action of the device shown similar to the former case since all axial motions of the body are transmitted to the hinged frame?

It would seem that much might be gained by providing for close adjustment of the axial plane of the balancing weights while the cage is in rotation, thus performing both operations without stopping to change the angular position of the cage.

Is the chain and gear drive free from vibrations which would affect the results?

THE AUTHOR REPLIES TO POINTS RAISED IN THE DISCUSSION

THE AUTHOR. In explanation of the several points brought up by those who have discussed my paper, I will review three of these discussions:

Mr. Loring. Unfortunately no explanation or reasons are given to justify the several assertions which comprise this discussion. I will consider each paragraph separately.

1 The definition of dynamic balance is objectionable because it involves a conception of higher order; if one knows what an unconstrained axis is, no definition of what constitutes dynamic balance is needed. Furthermore, an axis, being a straight line, cannot very well be *concentric* with anything. This, of course, may be only a *lapsus linguae;* but meant as a correction it is out of place.

2 Regardless of what the high spots show (in general they mean nothing at all), it was explained in the paper that the unbalance can only be due to a couple, provided that the body is in static balance; remove the couple and the body is in balance. This is actually being done every day in our shops, and by the users of these machines.

3 That the wire rope suspension is the most irrational of all methods that can be conceived follows from the fact that here we have the case of a so-called system with four degrees of freedom; in other words, there are four different ways in which such a system can oscillate, all confusing one another. There is absolutely no hope in this method.

4 So far as the possibility of placing a body in balance in two or three "shots" is concerned, I will merely ask this

[1] Fulton and 6th Streets, Troy, N. Y.

question: Who has ever said, or on what machine was it ever proved, that the body was really placed in balance? Is it because the operator himself said so? Is it because a machine, wrongly constructed upon a radically wrong idea, showed so? Is it not clear that it is absolutely impossible to secure any such result in three shots, except if the machine is so constructed that it shows balance where no balance exists?

5 Here are two examples showing that slow speed may be very conclusive indeed: 21-in. blowers are being balanced on our machine at 450 r.p.m., and operate at 800 to 1300 r.p.m. very satisfactorily; by older methods no such satisfaction could have been secured at all. Another rotor was balanced by us at 350 r.p.m. and ran very well at all speeds, including its highest speed of 2500 r.p.m. There is nothing unusual about this. Balance is balance; if the rotor is so constructed that it changes its shape with the speed, it should be thrown away, because it cannot be balanced at all. But of course supposed illusory balance may show one result for a low speed and another, quite different, for higher speeds.

Mr. Hodgkinson's discussion in defense of what he calls "older methods" contains a number of weak points, with which I shall deal separately.

1 There is no secret about the details of construction of the cage. It can be (and is being) made in a great many different manners, each of which yields the same result, and the description of all such types would take up much space, without being instructive or interesting. The main principle is that the rods can be displaced while the cage is in rotation.

2 To Mr. Hodgkinson "it seems evident that the spring support on one end should have a natural period or oscillation equal to the period of revolution of the body being balanced. This, of course, would mean a different spring for each different weight of body applied . . ." As a matter of fact, however, this is not only not evident, but it is not even so! By writing down the easy differential equation controlling this small oscillation, it will be seen that the free period depends not only on the weight but upon three other things, so that it is perfectly possible to imagine a great variety of different weights which would not necessitate any change whatsoever in the spring support. Full advantage is being taken of this fact in the arrangement of the machine, which is such that the operator has no calculations to make. This is a vital point that has been carefully considered in the design of my machine.

3 Mr. Hodgkinson does not seem to like my speaking "very disparagingly of older methods," but I must nevertheless go further and actually deny their very existence as methods. They are not methods at all. They never did or can give accurate results and there is a very definite logical reason why this is so: they are all concerned with what is known as *multiple degree of freedom,* the one-point (cone) suspension method involves freedom of two degrees; the floating bearing principle also involves two degrees; while the flexible rope suspension method involves no less than four degrees of freedom. All this means that the body being tested does not vibrate in just one way, from which some sort of an indication of value can be derived. Actually it vibrates in two or even in four entirely independent manners, each introducing new confusion into the already complicated motion. The machine described in the paper is to my knowledge the only one ever proposed involving but *one degree of freedom,* namely plane oscillations about the hinge; this is why balance shown on this machine is actually real, perfect balance.

4 Excessive confidence in the high spot methods, together with the hope that it is at all possible (which it is not) to balance "one end at a time," are precisely the reasons why it is necessary "frequently to perform balancing in the field." There is no necessity for doing this if real balance has first been secured in the shop.

5 Mr. Hodgkinson states that in the shops of the company by which he is employed, balance of small rotors is being "successfully" secured on a floating bearing machine. From all I heard and saw personally regarding this matter, his statement is entirely at variance with the facts.

Mr. Fairfield describes a typical floating bearing machine, which, however, has the fundamental error of a machine possessing two degrees of freedom. I have elsewhere advanced a few logical reasons showing why no machine with more than one degree of freedom can possibly secure dynamic balance. One of the features especially detrimental to the machine described by Mr. Fairfield is the belt drive. Since the bear-

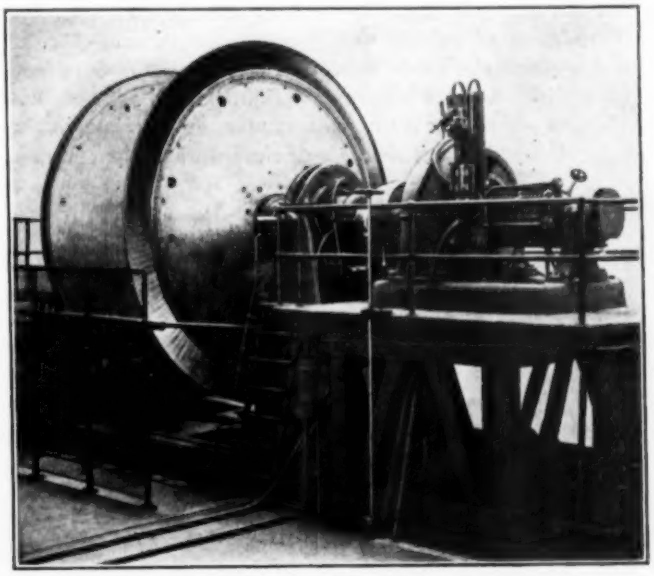

Fig. 16 Typical Horizontal Balancing Machine

ings are of the flexible or yielding type, it is a most unwise plan to drive from an outside source of power, no matter where located. Another notion which should have been exploded long ago is that of the so-called *critical speed.* I am fully aware of the tremendous amount of brilliant work that has been done by the English and German mathematicians in connection with this delicate subject, but that particular critical speed is one thing, and the speed at which the floating bearing machine changes its spots, whatever they are, is another thing, the two having no connection whatsoever. In the floating bearing machine we have the influence of the yielding nature of the bearings and of the twofold freedom; but there is nothing critical about it and certainly nothing from which any sort of valuable information may be obtained in regard to balance or unbalance of the body. It is not clear what started this idea of critical speed, but inasmuch as it does not correspond to anything of value and is misleading, it should be dropped once and for all.

In conclusion, the trouble with an understanding of what constitutes dynamic balance is that it is based on the presence (or absence) of certain quantities called "products of inertia" with which the practical man is in general quite unfamiliar. I did not wish to introduce the products of inertia in my paper and for this reason had to explain things by

something easier, the centrifugal couple, although this meant a much longer explanation. But I have seen some big practical men think the matter over and thoroughly digest the meaning of the expression *centrifugal couple,* after which, according to their own testimony the "thing came as clear as daylight" to them, which, however, is only too natural, because it is based upon common sense pure and simple; only it takes a little dynamics to put matter into an easy shape in which common sense can grasp the real meaning of this would-be elusive conception *dynamic balance.*

The principle of my machine has been worked out in a purely deductive, analytical way, and not by building up or by cut-and-try process. To begin with I had this problem in mind: how to tilt the momental ellipsoid so that its axis, the nearest to the axis of rotation, will be brought into absolute coincidence with the latter. This can easily be done by building the cage around the body, which is correct, although in the immense majority of cases, impractical. From this it was but one step to splitting up the body and the cage.

Inasmuch as we deal with couples, that is, moments, there was nothing else to do, except writing down the equation of the oscillation of the beam and working out the parts in detail. This did not require a single assumption or postulate, but was derived directly from elements of rigid dynamics.

In the matter of dynamic or running balance, Charles L. Clarke says, in effect, that since it is necessary only that the center of gravity of each elemental or narrow cross-section of a body shall lie in the axis of that body's rotation, in order for them to be in dynamic balance, this condition can be secured for them with practical accuracy, in the majority of cases of machine design, by the method of standing or static balancing of a sufficient number of sections in this manner before they are finally assembled, and thus assure the sought for dynamic balance of the body as a whole.

Static balancing has its practical limits, however, as many bodies are not separable into sections along the axis of rotation, or the shaft, if the body be one so mounted, for individual balancing, and hence must be balanced as a unit.

The balancing of machines having connected and oscillating and reciprocating members is a complicated compromise between purposely produced surplus dynamic effects of out-of-balance rotation of one body and the dynamic effects of other connected non-rotating but moving bodies. The balance at best is a rough one.—*General Electric Review,* July, 1916.

Concerning the strength of oxy-acetylene welds, S. W. Miller says that in the case of ordinary cast iron it is well known that the weld is stronger and less brittle than the original material, due to the finer grain resulting from the good quality which it is imperative that the welding rods shall have.

With steel the situation is very complicated owing to its many kinds and purposes of use and hence its many kinds of stresses.

Hardness and ductility are relative terms, and a weld in a very soft, ductile, low-carbon steel may be harder than the original material, while a weld made with the same welding wire in a much harder steel of higher carbon may be softer than the original material.

Microscopic examinations indicate that it is impossible to weld high carbon steel without burning it.

With steel of about 55,000 lb. tensile strength, a welded piece will usually locate in the weld, at a tensile strength of about 52,000 lb. The elongation may run as high as 20 per cent, that of the original material being, perhaps, 32 per cent, and the elastic limit will be about 33,000 lb. against 35,000 lb. for the original material.

Referring to welds in non-ferrous metals, Mr. Miller says that in a general way if the welds are carefully made with a good torch and proper materials the results will usually be satisfactory.—*Machinery,* vol. 22, no. 10, June 1916.

The Swedish State Railways have requested the king to propose a bill for an appropriation for the erection of a peat powder factory for use as a locomotive fuel. After a careful examination the railway directors state, according to a report transmitted by Ira N. Morris, American Minister at Stockholm, that they have found peat powder to be very efficient and practical for locomotives, with a fuel value compared with that of coal of about 2 to 3. Using the ratio given and calculating from the lowest estimate for the production of peat powder, the cost of the latter per ton would be $4.02 with a corresponding price of coal of $6.03 per ton.—*Railway Review,* June 24, 1916.

Condenser tube troubles prompted an investigation which was conducted by Prof. A. E. White in 1913 for the Edison Illuminating Company of Detroit. The results are presented in a paper read at the annual meeting of the American Society for Testing Materials, held at Atlantic City, June 30, 1916.

The purposes were to ascertain the reason for the splitting of brass condenser tubes in service; to determine the proper chemical composition, and the mechanical and heat treatments which should be given to the tubes; and to formulate such specifications as would be of material aid in their purchase. The specifications finally arrived at completely eliminated the troubles previously encountered.

To ascertain whether or not the splitting was due to impurities, chemical analyses were made, which showed that the proportion thereof was very small and evidently not the source of failure. This was later found to be due to defects in the making, particularly in the drawing and annealing. The composition of the material of the tubes, as shown by the analyses, was more or less uniform—60 parts of copper to 40 of zinc—Muntz metal. An alloy of 70 per cent copper and 30 per cent zinc is considered to be the best in the presence of fresh unpolluted water, while if the water be polluted, or with salt water, one of 70 per cent copper, 29 per cent zinc and 1 per cent tin is excellent. The first named alloy is preferred as it embodies the maximum ductility of all the brasses, and because it lends itself better to cold working and annealing. Further electrolytic action is not possible.

For condenser tubes ductility rather than tensile strength is one of the governing factors and this the 70 to 30 mixture gives in greater measure than does one of 55 per cent copper and 45 per cent zinc, which has the greater tensile strength.

Cold drawing, when not too severe, assures a breaking down of existing crystallization, resulting in both smaller and better interlaced grains. It also makes annealing necessary between each set of cold drawings, both of which processes improve the quality of the tube. Too much cold drawing between annealings will distort the grain structure to such an extent as to produce heavy slip bands which are almost impossible to eliminate. It is more desirable to reduce the thickness of the tube by many light drafts than by a few heavy drafts. Not less than six drawings should be made, and twelve or even more cold drawings are to be preferred.

ON THE TRANSMISSION OF HEAT IN BOILERS

BY E. R. HEDRICK,[1] COLUMBIA, MO., and E. A. FESSENDEN, COLUMBIA, MO.

Non-Member — Member of the Society

The authors have found difficulty in checking the results of experiments quoted in the literature with the theories commonly proposed for the transmission of heat from the hot gases to the water in a boiler.

They have been led to an assumption which seems particularly reasonable since the resistance to heat transfer changes almost certainly with temperature. The assumption is that the quantity of heat lost by a given small weight of gas falls off as the gas passes down the pipe in accordance with the ordinary damping law usual in physical phenomena.

The theoretical consequences of such an assumption are worked out in detail, and are brought to a point where graphical check with numerical data is easily possible.

THE inadequacy of certain current theories of heat transmission in boilers,[2] and the difficulties experienced by the authors in attempting to check the theoretical formulae of Sir John Perry and others with the results of actual experiments quoted by Perry himself and by others have led to the outline of a new theory which agrees with known experiments to within reasonable limits of possible error.

Perry's[3] formula for the efficiency E of a tube length l is

$$E = 1 - e^{-cl/d} \qquad [1]$$

where e is the Naperian base 2.71828

c is a constant

d is the diameter of tube.

For any particular tube, c/d is a constant k, and denoting distances along the tube by x the equation may be written in the form

$$E = 1 - e^{-kx}, \text{ or}$$

$$\log_{10}(1 - E) = -Kx$$

where $K = k \log_{10} e$

From values of E given by Perry[4] for the famous French experiments, the authors have computed K by two methods; *first*, by dividing the difference between successive values of $\log_{10}(1-E)$ by corresponding differences in x, and *second*, by direct substitution in the equation $-K = \dfrac{\log_{10}(1-E)}{x}$.

If K were constant, as it should be if Perry's formula holds, the two methods would of course give identical results. Instead, the values of K diminish steadily as x increases, and the last value is only about one-third of the first value.

Fig. 1 shows clearly the same discrepancy. In it, values of $\log_{10}(1-E)$ are plotted against values of x. If Perry's formula [1] held, the resulting figure would be a straight line, which it clearly is not.

Similar data given by Kreisinger and Ray[5] show quite as great discrepancy. A considerable number of other sets of data are given in the authors' complete paper and these are compared in each case with the formulae of Perry and with those of this paper.

Perry's work is based on that of Osborne Reynolds. He makes the fundamental assumption that the amount of heat δH transmitted across a small length δx of the tube is proportional to the difference in temperature τ between the gas and the water, and to the area of the tube wall:

$$\delta H = b\tau\,\delta x \qquad [2]$$

where b is a constant.[1] This amounts to saying that the conductivity $\delta H/\delta x$ is a constant. From this he derives[2] the formula

$$\theta = \theta_1 e^{-cx/d}$$

where θ and θ_1 are equivalent to our τ and τ_0 and where c/d is a constant which we shall call c. Then

$$\log \frac{\tau}{\tau_0} = -cx, \text{ or } \tau = \tau_0 e^{-cx} \qquad [3]$$

where c is a constant, τ_0 is the value of τ at the fire-box end of the tube, and x is the distance along the tube, measured from the fire-box end.

A reasonable ground for the discrepancy in these formulae is to be found in the assumptions made by Perry of the constancy of heat conductivity, or its reciprocal, heat resistance. Everyone recognizes that the principal sources of heat resistance are the peculiar state and behavior of the gas and of the water next to the tube, rather than the intrinsic resistance of the tube wall itself, the total being of the order of one thousand times the intrinsic resistance of the tube wall alone, yet the effect of these peculiar conditions is apparently neglected.

The phenomena present around the walls of the tube depend upon temperature, as does the speed of the gas which contracts with cooling. The resistance itself, therefore, depends upon temperature, if we mean by resistance that total mentioned above rather than the intrinsic resistance of the metal alone. This explains why a discrepancy should be present in the Perry theory, and furnishes a basis for the assumptions to be made.

The original assumption is that as we proceed down the tube, the amount of heat loss from a small quantity of gas δQ occupying a length δx of the tube, in passing a given point, falls off according to the usual formula for any damping out process so that

$$\textit{loss of heat in } \delta Q = ce^{-mx} \qquad [4]$$

where m and c are constants.

It is assumed that the decrease $\delta\varphi$ in the entropy of the gas in a small section of the tube of length δx is proportional to

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[2] See for example Perry, The Steam Engine, 1909; and Bulletin 18 of the U. S. Bureau of Mines, by Kreisinger and Ray, entitled The Transmission of Heat into Steam Boilers.

[3] Perry, l.c., p. 59A.

[4] Perry, l.c., p. 432.

[5] Bulletin 18, U. S. Bureau of Mines, p. 53, fig. 16.

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[1] The constant b depends upon and changes with the diameter of the tube, the gas velocity and other variable phenomena connected with the experiment, but is supposed to be the same throughout any one experiment.

[2] Perry, The Steam Engine, 1909, pp. 587-591.

the entropy difference $\varphi - \varphi_w$, where φ is the entropy of the gas at the temperature of the gas and φ_w the entropy the same gas would have at the temperature of the water.

Since φ_w is constant, $\delta\varphi_w$ is zero, and $\delta\varphi$ equals $\delta\,(\varphi - \varphi_w)$, and the fundamental assumption may be written in the form

$$\delta\,(\varphi - \varphi_w) = -\,m\,(\varphi - \varphi_w)\,\delta x \qquad [5]$$

where m is a positive constant. The following well known relations are also used:

$$\delta\varphi = \delta H/\theta \qquad [6]$$

$$H = c_p\theta \qquad [7]$$

$$\delta\varphi = c_p\,(\delta\theta/\theta) \qquad [8]$$

where θ is the absolute temperature

H is the heat content of unit weight

c_p the specific heat at constant pressure.

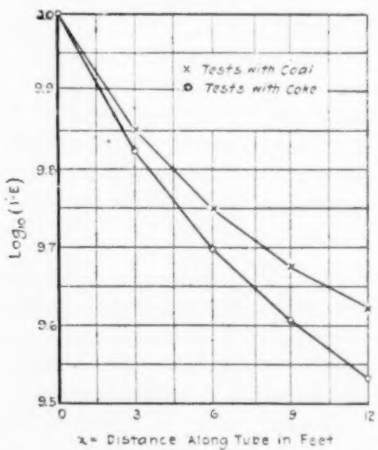

FIG. 1 FRENCH EXPERIMENTS, PERRY'S FORMULA FOR EFFICIENCY OF BOILER TUBE

We assume c_p constant, and the pressure p in the tube constant.

From [8]

$$\varphi - \varphi_w = c_p \log_e \frac{\theta}{\theta_w} \qquad [9]$$

and therefore [5] becomes, in the limit as δx approaches zero,

$$\frac{d \log_e\,(\theta/\theta_w)}{dx} = -\,m \log_e\,(\theta/\theta_w) \qquad [10]$$

If we denote $\log_e\,(\theta/\theta_w)$, which is proportional to $\varphi - \varphi_w$, by s, we have

$$\frac{\delta s}{dx} = -\,ms \qquad [11]$$

whence by integration

$$\log_e s = -\,mx + \kappa \text{ or } s = ke^{-mx} \qquad [12]$$

where κ and k are constants, and where $\kappa = \log_e k$. If $x = 0$, s has the value $s_0 = \log_e\,(\theta_0/\theta_w)$, where θ_0 is the absolute temperature of the gas as it enters the tube. Hence, inserting these values, $k = c_0$ or $\kappa = \log_e s_0$; and [12] may be written in the form

$$\log_e\,(s/s_0) = -\,mx \text{ or } s = s_0\,e^{-mx} \qquad [13]$$

In terms of θ these formulæ are

$$\log_e(\theta/\theta_w) = \log_e(\theta_0/\theta_w)\,e^{-mx} \quad \text{or } \theta/\theta_w = (\theta_0/\theta_w)\,e^{-mx} \qquad [14]$$

For comparison with numerical data it is desirable to have these formulæ expressed in common logarithms. Remembering that

$$\log_{10} N = \log_e N \times \log_{10} e$$

we may write the formula [14] in the form

$$\log_{10}\,(\theta/\theta_w) = \log_{10}\,(\theta_0/\theta_w)e^{-mx} \qquad [15]$$

Let us set

$$R = \log_{10}\,(\theta/\theta_w) \text{ and } R_0 = \log_{10}\,(\theta_0/\theta_w)$$

so that R is proportional to s used above, or to $\varphi - \varphi_w$. Using this notation, and taking common logarithms again, we have

$$\log_{10} R = K - Mx \qquad [16]$$

where

$$K = \log_{10} R_0 = \log_{10}\,[\log_{10}\,(\theta_0/\theta_w)], \text{ and } M = m \log_{10} e$$

In the numerical computations of this paper the quantities θ, θ/θ_w, R, and $\log_{10} R$ are tabulated in that order. Denoting the last of these by Φ

$$\Phi = \log_{10} R = \log_{10}\,[\log_{10}(\theta/\theta_w)] \qquad [17]$$

and we have

$$\Phi = K - Mx \qquad [18]$$

where K and M are constants defined above.

Prof. William Kent provides a set of direct temperature measurements in a locomotive boiler tube at every foot of its length. These measurements and the corresponding values of

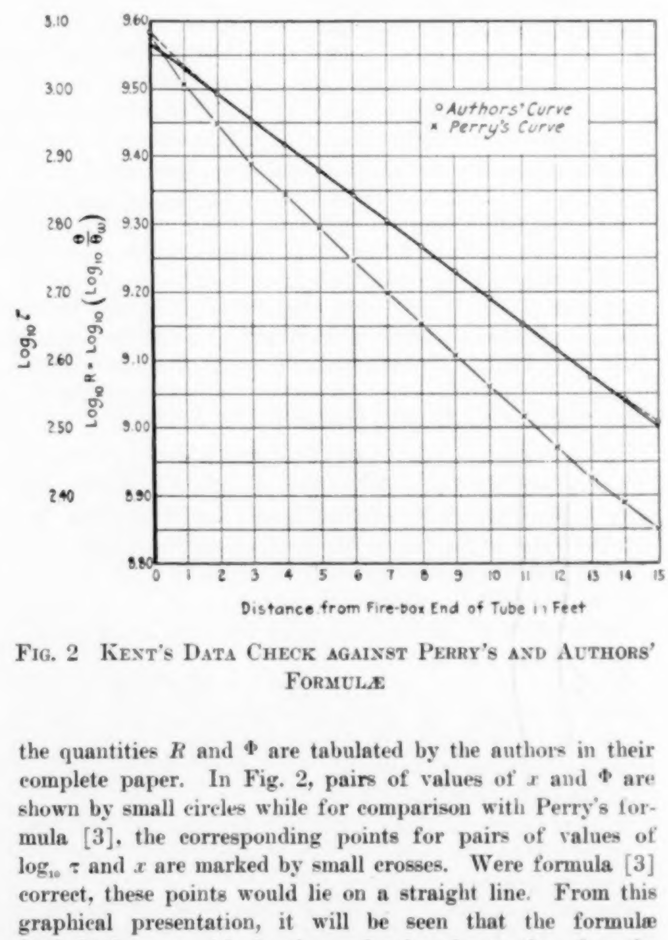

FIG. 2 KENT'S DATA CHECK AGAINST PERRY'S AND AUTHORS' FORMULÆ

the quantities R and Φ are tabulated by the authors in their complete paper. In Fig. 2, pairs of values of x and Φ are shown by small circles while for comparison with Perry's formula [3], the corresponding points for pairs of values of $\log_{10} \tau$ and x are marked by small crosses. Were formula [3] correct, these points would lie on a straight line. From this graphical presentation, it will be seen that the formulæ [14]–[16] agree with the observed values better than does the formula [3].

Evidence of error in measurement due to the radiation from the thermal couple exists in the diagram, making it reasonable to give less weight to the extreme points.

The complete paper contains tables and diagrams from data

of further tests in support of the theory of the authors, and confirmation is evident in tests made by Professor Fessenden to be published.

To convert the preceding equations into forms which can be compared with these measurements, let us return to equation [9], and let us substitute in it from [7] where H means the heat content reckoned from $H = 0$ at $\theta = 0$. We have then

$$\varphi - \varphi_w = c_p \log_e (H/H_w) \qquad [19]$$

and the further reduction is precisely similar to that above, with the ratio H/H_w in place of the ratio θ/θ_w. Hence we have, as in [14]

$$\log (H/H_w) = \log_e (H_o/H_w)\, e^{-mx}, \text{ or } H/H_w = (H_o/H_w)^{e^{-mx}} \qquad [20]$$

and also, as in [16]

$$\log_{10} [\log_{10} (H/H_w)] = K - Mx \qquad [21]$$

where

$$K = \log_{10} [\log_{10} (H_o/H_w)], \text{ and } M = m \log_{10} e \qquad [22]$$

The authors have checked formula [20] with the experiments mentioned in precisely the same manner as formula [16] was checked with direct temperature measurements. In all of about forty experiments plotted by the authors, the agreement with the theory is at least as good as those published in their paper, while in the corresponding curves for Perry's formula there is a consistent tendency to be low in the middle.

The relation between M in equation [21] and the weight of gas per minute is shown graphically in Fig. 3 in which

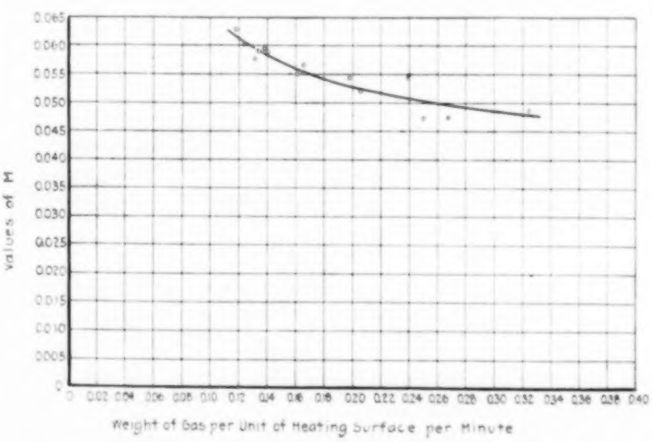

FIG. 3 VARIATION OF M IN EQUATION [21] WITH WEIGHT OF GAS PASSING THROUGH TUBE

these two quantities are plotted against each other from pairs of values found in a series of nineteen experiments using a standard 2-in. boiler tube with different furnace temperatures and gas velocities. Other experiments, not yet sufficiently complete, in which smaller tubes are used, seem to indicate that M also varies with the size of the tube. The data are not yet sufficiently complete to warrant a definite conclusion as to the exact nature of this dependence, except that M is larger for small tubes than for large tubes.

If M were constant for all gas velocities, it would follow that the boiler efficiency would be constant for all rates of driving. The decrease in the value of M is in accord with observed practice, since it shows that the efficiency decreases as the boiler is forced.

If the efficiency E of a tube of length x be defined as the heat absorbed in that length of tube divided by the total heat content of gases reckoned above water temperature, we have

$$\left(1 - E\right) = \frac{H - H_w}{H_o - H_w} = \frac{H_w}{H_o - H_w} [\, (H_o/H_w)^{e^{-mx}} - 1] \qquad [23]$$

where $\qquad m = M \log_e 10 = 2.3026 \times M$

The rate of drop in temperature along the tube is expressible readily on carrying out the indicated differentiation in [10]; this gives

$$d\theta/dx = -m\theta \log_e (\theta/\theta_w) \qquad [24]$$

or, by [14]

$$d\theta/dx = -2.3026\, m\, R_o\, \theta\, e^{-mx} \qquad [25]$$

Since the volume of a given weight of gas is proportional to its absolute temperature θ, the weight of the amount of gas δQ in a section of length δx is inversely proportional to θ, and we have

$$\textit{loss of heat in } \delta Q = + c e^{-mx}$$

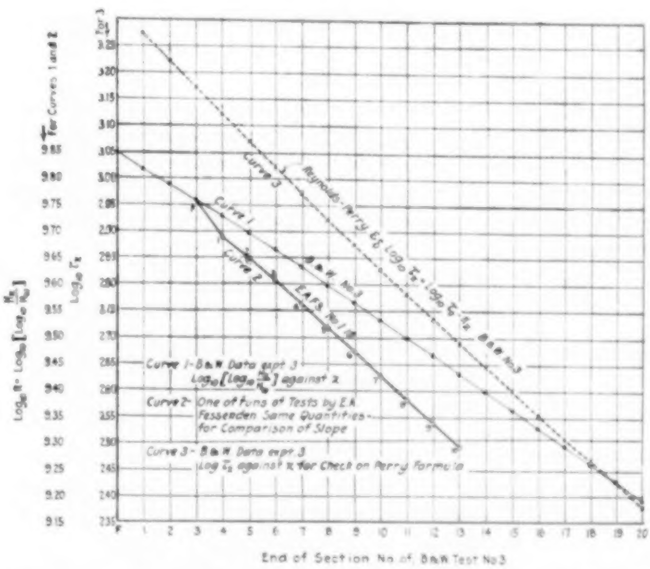

FIG. 4 BABCOCK & WILCOX EXPERIMENTS NO. 3 CHECK AGAINST PERRY'S AND AUTHORS' FORMULÆ

which agrees with [4], and shows the equivalence of the fundamental assumptions mentioned at the beginning.

Finally, the conductivity and its reciprocal, the resistance, may be formulated. The conductivity γ is

$$\gamma = c_p m \frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w = c_p m \theta \frac{\log \theta - \log \theta_w}{\theta - \theta_w} \qquad [26]$$

Since we have for values of θ less than twice θ_w the series

$$\log \theta - \log \theta_w = \frac{1}{\theta_w}(\theta - \theta_w) - \frac{1}{2\,\theta_w^2}(\theta - \theta_w)^2 + \ldots$$

we have also

$$\gamma = c_p m \frac{\theta}{\theta_w}\left[1 - \frac{1}{2\,\theta_w}(\theta - \theta_w) + \ldots\right]$$

whence it follows that γ approaches $c_p m$ a limit as θ approaches θ_w. The constant m which occurs throughout the preceding work may therefore be thought of as proportional to the limiting value of the conductivity as the temperature of the gases approaches that of the water. Thus the fact that the value of M, which is proportional to m, is smaller for a large pipe, may be interpreted to mean that the gases in the large tube have less contact with the tube wall per unit of volume.

In an addendum to their original paper, the authors have checked against their theory the results of a new series of experiments made by the Babcock and Wilcox Company. Due to the conditions under which the experiments were made, which differed somewhat from those under which Professor Fessenden made his experiments, the authors are of the opinion that the data should give points slightly low at the hot end, and also slightly low on the cold end.

The data computed by the authors are plotted in Fig. 4. It will be seen that the check, which again consists in the fact that points should lie on a straight line, is very good. There appears to be a slight lowering of the points at both ends, as would have been expected.

On the same figure, the authors have shown an attempt to check the data with Perry's formula. The points vary from a straight line in a manner similar to the behavior of other sets of data previously discussed.

The formulae given by other writers and in Bulletin 18 of the U. S. Bureau of Mines are substantially the same as Perry's. Unsatisfactory attempts have been made by the authors to check Jordan's formula.

The authors have checked through the assumption of Prof. William Kent (Steam Boiler Economy) that the rate of transmission is proportional to the square of the temperature difference. Using the Babcock and Wilcox data, it was found that the exponent of the temperature difference should be 1.2 instead of 2 or

$$q = \frac{(T - t)^{1.2}}{a}$$

instead of

$$q = \frac{(T - t)^2}{a}$$

with a of value about 400 to satisfy the tests. It should be noted that q is the rate of transmission per unit surface but not per degree difference in temperature. The formulae of Rankine are substantially the same as those of Kent.

The authors feel that the tests agree substantially with the theory they present, but do not agree with any other formulae known to them to the same extent.

DISCUSSION

F. E. Cardullo presented a written discussion in which he said that equation [4] of the paper, although appearing to be rational, could not represent any actual physical law as the quantity of gas considered was continually diminishing according to some law which was a function of x; and that the assumption that decrease in entropy in a small section of a tube of length δx is proportional to the entropy difference $\varphi - \varphi_w$ also appeared to be rational until, upon investigation, there was found to be no reason for believing that the entropy, or rate of change of entropy, had anything to do with heat transfer, the fact of its leading to a correct conclusion being a mere coincidence.

Since the velocity of gases flowing through a constant cross section will be greater at high temperatures, because of larger specific volume of gas, equations derived from assuming the rate of heat transfer proportional only to temperature difference will not represent the facts unless modified to take into account the well known fact of increased conductivity with increased velocity. Thus the empirical equation happily chosen by the authors, $Q = KT \log T/t$, where Q is the rate of heat transfer in B.t.u. per sq. ft. per hr., T the absolute temperature of the gas at the given point, t that of the water, and K an experimentally determined constant, depending, among other things, upon the weight of gases flowing through the cross section in a given time, leads to astonishingly accurate results, while the usual assumption, that $Q = K(T - t)$, gives systematic, though not serious, inaccuracies.

The equation from Perry is manifestly untrue unless we assume that the air supplied to the fire is at the same temperature as the water in the boiler.

The authors' equations, neither leading to new conclusions regarding boiler design, nor modifying appreciably our ideas of the rate of heat transmission, represent a refinement of accepted theories in an unfortunately cumbersome form, although simpler equations, representing the facts as accurately or through as wide a range probably cannot be discovered.

William Kent, in a written discussion, pointed out that the chief value of the paper lay in its proof of the invalidity of the formulae of Perry and Reynolds which are based on

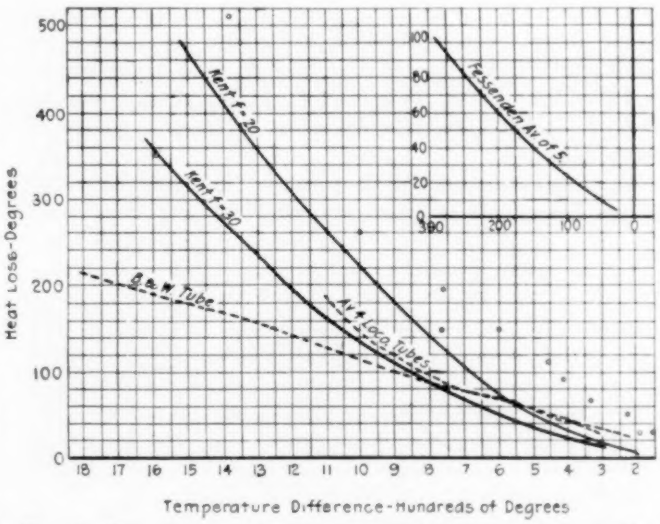

Fig. 5 Relation of Heat Loss to Mean Difference Between Temperatures of Gas and Water

the assumption that the heat transmitted varies directly as the difference in temperature.

The results of boiler tests given in the authors' paper and accredited to Professor Kent are the averages of four tests made by C. B. Young and also given in the authors' paper.

His discussion presented a comparison of figures obtained by averaging Mr. Young's tests with the average of Professor Fessenden's five tests, the results of the Babcock and Wilcox test and the results of computations of two hypothetical cases, based on Rankine's formula, which differ only in the amount of gases ($f = 20$ and $f = 30$) per pound of fuel. (See Steam Boiler Economy, 2nd edition, p. 310.) Taking the difference in temperatures of two successive sections as a measure of the loss of heat by the gas and of the heat transmitted to the water, and the mean difference of the temperature between the gas and the water as the average of the temperatures at the beginning and at the end of a section, minus the constant temperature of the water, a table was constructed showing the relation of the heat loss to the mean difference between the temperatures of the gas and water. These figures are plotted on the diagram shown in Fig. 5.

It is interesting to note that the hypothetical curve for $f = 30$ agrees almost exactly with the four locomotive tube

tests between 1100 and 700 deg. temperature difference, but below the lower temperature, the curve merges with the curve of the Babcock and Wilcox tube. The curve of the Fessenden tube shows a steeper inclination between $(T_1 - t) = 297$ and 157 than it does at the lower temperature range, from $(T_1 - t) = 157$ to 33, while the curve of the Babcock and Wilcox tube shows a considerably flatter inclination at the higher than at the lower temperatures. All the curves, except that of the Babcock and Wilcox tube, show a distinct tendency to becoming convex to the axis of the abscissae. The Babcock and Wilcox tube curve cannot be made to fit the equation of any curve unless two of its points, $(T_1 - t) = 1350$ and 1246 are shifted downwards, when it becomes a straight line, indicating that the transmission of heat is proportional to the difference in temperature, which is contrary to all the other curves. The curves of the Fessenden tests coincide nearly with two straight lines of differing inclination. From $(T_1 - t) = 297$ down to 157, the loss of heat is $0.37(T_1 - t)$, while from $(T_1 - t) = 157$ down to 33, the loss is $0.29\ (T_1 - t)$.

The result of over thirty years' study has led Professor Kent to the conclusion that for boilers driven at a rate above

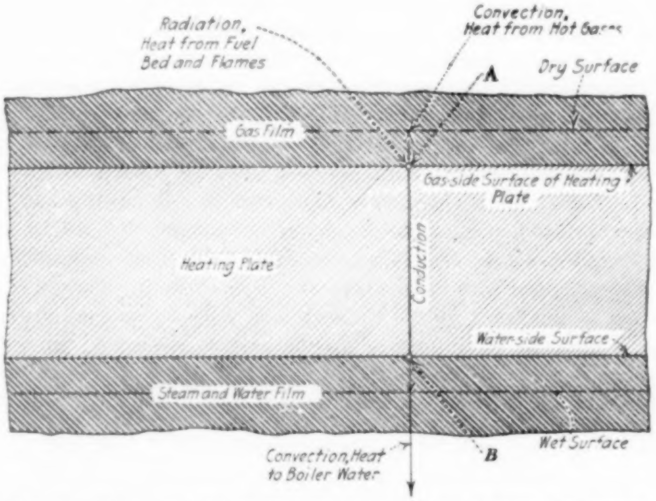

FIG. 6 PATH OF HEAT TRAVEL FROM HOT GASES THROUGH HEATING PLATE INTO BOILER WATER

3 lb. evaporation per sq. ft. of heating surface per hr., at which the radiation loss is small, the formula for boiler efficiency is that of a straight line, $E = A - B(W/S - 3)$ in which A is the maximum efficiency at the 3-lb. rate of driving, W is the pounds of water evaporated from and at 212 deg. per hr., S is the square feet of heating surface, and B is an experimental coefficient, the value of which depends chiefly upon the amount of air per pound of fuel, but also upon the completeness of combustion and the cleanness of the heating surface. It apparently has no relation to the velocity of the gases.

The derivation of the straight line formula will be found in Kent's Steam Boiler Economy, 2nd edition.

Mr. Kent suggests the development of a formula based upon the assumption that the transmission of heat is $(T - t)^x \div a$, in which x is an exponent other than 2, say 1, 1.2, or 1.5.

HENRY KREISINGER[1] and J. F. BARKLEY[2] presented a written discussion in which they reviewed the modes of heat propagation discussed by them in various publications.[3]

[1] Engineer, U. S. Bureau of Mines.
[2] Junior Electrical Engineer, U. S. Bureau of Mines.
[3] Bulletin 18, and Technical Paper 114, U. S. Bureau of Mines.

Fearful that the authors of the paper measured the temperatures in a manner not sufficiently accurate, Messrs Kreisinger and Barkley reviewed the reasons for and seriousness of these possible inaccuracies. From diagrams made by them from actual measurements, they show that temperature measurements taken in the centre of a boiler tube can not prove or disprove any theory of heat transmission.

The original equation of Reynolds,[1] $H = A\,(T - t) + B(T - t)qv$, not touched upon by the authors, applies to the convection part of the heat transmission in Fig. 6, stopping at the dry surface and not extending through the plate to the water; that is, t is the temperature of the dry surface. Perry distinctly states that t is the temperature of the film of gas next to the water. Further in his discussion,[2] he considers the

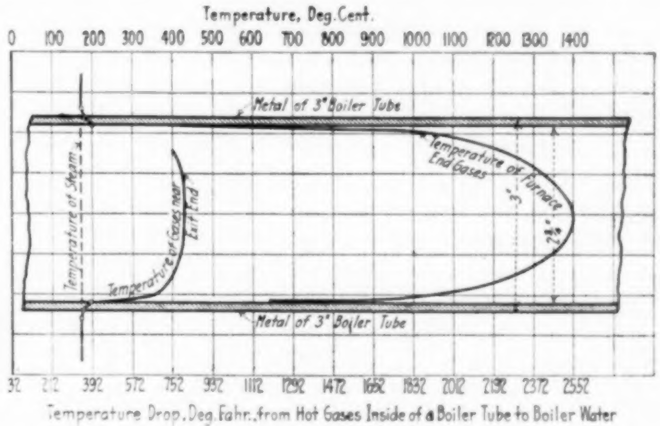

FIG. 7 TEMPERATURE DROP FROM HOT GASES IN BOILER TUBE TO BOILER WATER

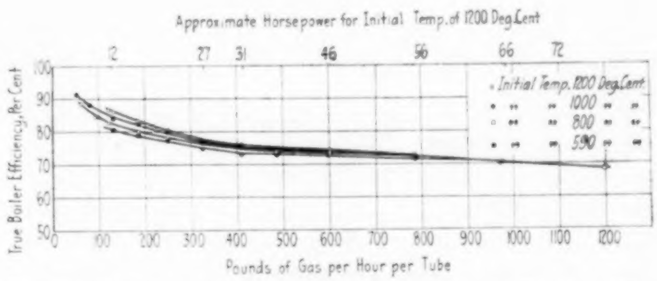

FIG. 8 TRUTH OF PERRY'S FORMULA WHEN BOILER RECEIVES HEAT ONLY BY CONVECTION

change in conductivity of the gas film and its effect upon t, obtaining an expression which includes the probable thickness and conductivity of the film as the velocity of the gases and their temperatures vary. He concludes that in existing boilers, the resistance of the metal itself is insignificant, but as better circulation is provided on both sides of the metal the total resistance must approximate more and more that of the metal itself. A footnote adds, "The above investigation shows that the following simple way of putting the whole matter is legitimate within certain limits of velocity, etc."

Perry then develops the simple form of equation used by the authors, $\theta = \theta_1\, e^{-cx}$, in which θ is the difference in temperature at any point along the path of the gases when the initial temperature θ_1 is given. In Fig. 4, the points obtained with the simple Perry expression are about as much one way from a straight line as the points derived from the authors' formula are the other way.

[1] Bulletin 18, Bureau of Mines, p. 114.
[2] Perry, The Steam Engine, 1909, p. 588.

Fig. 7 shows that the largest temperature drop is in the layer of gas about 1/8-in. thick next to the wall of the tube, and only a very small drop from the gas side surface of the t tube through the metal and through the water film to the boiler water. The problem is to get the heat from the gas into the metal of the heating plate.

Perry's simple formula gives an expression for true boiler efficiency which is independent of the initial temperature. How nearly this is true when a boiler receives heat only by convection through its flues is shown in Fig. 8, which gives the results of some experiments. When a small weight of gas flows through the tube and the velocity is low, the efficiencies for 1200 deg. cent. and 600 deg. initial temperature are 4 or 5 per cent apart. As more gases are pushed through the tube at high velocity, the scrubbing effect increases, and the efficiency curves for the different temperatures come together. There seems to be considerable range, both as to temperature and weight of gas, for which the formula can be applied with but little error.

JOHN E. BELL,[1] in a written discussion, pointed out that the constant m in the authors' equation (24) has the dimension L^{-1} and is independent of θ, but depends on the physical characteristics of the gas, the velocity of flow, and the dimensions of the channel.

Introducing the entropy of the gas, particularly as a mean value, seems unwarranted, and certainly equation [8] is incorrect. The left hand side of this equation is the variation in the mean entropy of gas passing any section of the tube for a slight variation in the location of this section along the tube. This mean entropy must be measured in the same way as the mean temperature, which is found by averaging over the whole section, taking into account both the variation in temperature and the variation in velocity of flow. The mean entropy would be figured in this way, and equation [8] would not hold under these conditions.

If R represents the rate of heat transfer under different conditions, W the weight of the gas flow, and S the surface per unit length of channel, then, otherwise using the notation of the authors' paper,

$$\frac{d\theta}{dx} = \frac{-RS}{c_p W}(\theta - \theta_w)$$

Comparing this equation with equation (24) it is seen that

$$R = \frac{mc_p W}{S} \cdot \frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w$$

which is equation (26) of the paper with a little different notation. If this equation be correct, the transfer rate is the product of two factors, one $\frac{mc_p W}{S}$, independent of the temperatures and dependent on the weight flow and the dimensions of the channel, the other $\frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w$, independent of the weight flow and channel dimensions and dependent on the temperature of the gas only.

Experimental data published by the Babcock and Wilcox Company and dealt with in the authors' addendum shows that

$$R = a + bw$$

where a is a constant independent of the temperature and gas flow, b is a coefficient that varies with the temperature, and w is the weight of gas per sq ft. of flue area per hour. This cannot be of the form above unless the constant a has a zero value. Reynolds, Perry and other writers who have followed them, have assumed that such is the case, and have been led into conclusions which are not checked by facts. The experiments of the Babcock and Wilcox Company give to a the value 2.1, and the experiments of Jordan assign even a greater value. Since the value of this constant is unquestionably independent of the temperature, it appears that the law proposed in the paper can be only approximately true. It does not seem that Professor Fessenden's experiments were worked up to a point where the comparison made above could be satisfactorily carried out.

[1] 111 Broadway, New York.

LAWFORD H. FRY presented a written discussion in which he pointed out that the constants in the authors' empiric formula for transmission of heat along a boiler flue are constant only for each particular case, no means being offered by which the constants can be determined for varying conditions. Furthermore, it should be borne in mind that the temperatures measured in the flue in the tests of locomotive boiler tubes cited by the authors are probably affected by radiation to the walls.

If a general formula for heat transfer is to be established, it must take into account the nature of the gas flowing in the flue, the rate of flow, the dimensions of the flue, and the variation, if any, of the temperature along the wall of the flue. On such an equation, work has been done by Nüsselt (*Zeitschrift des Vereines deutscher Ingenieure*, 9 July, 1910) and by Leprince-Ringuet (*La Revue de Mécanique*, No. 1911). It would also seem necessary to take into account the variation in specific heat with the temperature. Equations for this variation as published by the Babcock and Wilcox Company are cited, and the instantaneous specific heat is calculated, for a smoke box gas of composition, $CO_2 = 11.1$ per cent, $O = 6.9$ per cent and $N = 82$ per cent, to be 0.2568 at 400 deg. fahr. and 0.3019 at 2000 deg.

THE AUTHORS. We are pleased to note that most of those who comment upon our paper agree that our formulae represent experimentally observed facts better than other proposed formulae. We regret that Messrs. Kreisinger and Barkley fail to appreciate this close agreement.

The original Reynolds-Perry equation used by the Bureau of Mines, and quoted by Messrs. Kreisinger and Barkley,

$$H = A(T - t) + B(T - t)qv, \qquad [1a]$$

we prefer to write in the form

$$H = (A + Bqv)(T - t). \qquad [1b]$$

In this form, q is the density and v the velocity of the gas. Then qv is proportional to the weight of gases passing, hence

$$H = (A + Bw)(T - t) \qquad [1]$$

In any single experiment, the weight of gases passing must obviously be the same for all parts of the tube, hence, for any single experiment, the equations above reduce precisely to a statement that the heat transmitted is proportional to the temperature difference, and lead directly to what we have called Perry's formula. Hence the statement that this formula was not touched upon in our paper is only superficially true. It should be obvious that a test of what we call Perry's formula should also be a test of this one.

Possibly formula [1] might be made to fit experiments if

the quantities A and B are admitted to be variables and not constants. Our own tests, as well as those of the Babcock and Wilcox Company, indicate clearly that B is itself a function of the temperature difference, which varies along the tube, and possibly also of the physical properties of the gases. These experiments also indicate that A probably varies with $(T - t)$.

We agree thoroughly with Messrs. Kreisinger and Barkley that temperatures measured by thermocouples placed in the tubes are highly unreliable. (See par. 27 and 28 of original paper). The Fessenden experiments were conducted by almost precisely the same methods as those used in the Babcock and Wilcox experiments. In neither were direct temperature measurements used, except at the end of the tubes.

Mr. Bell, quoting from the bulletin describing the Babcock and Wilcox experiments, uses the formula

$$R = a + bw \qquad [2]$$

to express the heat transfer rate. This is identical with equation [1] above except that b is a variable depending upon the temperature difference instead of a constant. It should be noted that the Babcock and Wilcox bulletin (p. 66) calls attention to the fact that the straight lines shown on the chart referred to are in reality secants or tangents to curved lines which really represent the facts. The same bulletin also shows that a varies with the weight; and we have some evidence, though not entirely conclusive, that a is also a function of the temperature difference. It would thus appear that equation [2] should be

$$R = u + vw$$

where u and v are functions of the temperature difference at least and probably also of other conditions. It then seems that equation [2] may in reality be simply the first terms of a series which might well be expressed by the logarithmic form we have used.

For Mr. Fry's information it may be stated that in all of our own experiments the specific heat of the gases was carefully taken into account.

It should be noted that in making his calculations upon the Fessenden experiments, Professor Kent has used the heat content of the gases above the water temperature instead of the temperature differences used in compiling other data, thus displacing the curve for these experiments far to the right of its proper place. We object seriously to the averaging of several tests; and wish to state that we did not know that the data so kindly furnished us by Mr. Kent was made up of averages from a number of Mr. Young's tests.

Professor Kent's contention that the boiler efficiency, and therefore the heat transfer rate, has no relation to gas velocity is manifestly incorrect. This has been shown by many experiments; and furthermore, Professor Kent's own formulae apparently take some account of gas velocity in that they employ the gas weight.

We do not understand Professor Cardullo's use of the term "rational" as opposed to "empirical." We contend that some assumption underlies every theory. We cannot conceive how any assumption can be called rational which does not check with experiment. The statement that the rate of heat transfer is proportional to the temperature difference is, in reality, an assumption; and as it is not borne out by experiment, why should it be styled "rational"?

A more complete presentation of the Fessenden experiments, together with detailed discussion of the results and the various constants and coefficients involved is now in preparation and will be published in the near future as a bulletin of the Engineering Experiment Station of the University of Missouri.

The Flow of Viscous Liquids Through Pipes has been investigated by the Research Laboratory of Applied Chemistry of the Massachusetts Institute of Technology and the results are given by W. K. Lewis in *The Journal of Industrial and Engineering Chemistry* for July 1916.

Mr. Lewis says that although our knowledge of the resistance to flow of water through pipe lines is relatively satisfactory and complete, there has been practically no publication on such resistance with liquids other than water, and a series of tests was made to study the flow of mineral oils of varying viscosity and at different rates of flow.

Liquids of even moderate viscosity flowing under low heads follow viscous motion unless the pipes be very large. It is very important to keep in mind the fact that, so long as the motion is viscous, doubling the size of the pipe increases the velocity four-fold and the discharge sixteen-fold for the same pressure drop. For the same discharge a pipe twice the size requires only one-sixteenth the pressure drop and, therefore, but one-sixteenth the power.

Introducing a paper on a description and tests of an eight-effect distilling plant, Frank T. Leilich says that all distilling plants are based upon the well-known principle that if water containing salts or other materials in solution or suspension be vaporized and the dry vapor condensed, the condensation will be free from impurities; but only, however, if the salts are not vaporized at or below the steam temperature.

In the distillation of sea water, apparatus for the production of pure water has, naturally, found its widest application in marine service, where it is imperative that "make-up" water for the boilers and also drinking water be supplied. Water containing up to 30 gr. NaCl per gallon may be used for drinking purposes, but it has a brackish taste.

Except where water is desired in very small quantities, the fuel consumption per gallon of output is perhaps the most important consideration, and the author mentions the logical development from the simple and familiar closed water vessel in combination with a coil condenser, heated by a gas burner, and very wasteful of heat, to the method of leading the steam from the closed vessel to tubes or coils immersed in water in a second similar vessel, known as an "effect," and thus cause the heat of the steam to evaporate water in the second effect, from which the steam may be lead to a third effect. In actual practice the first closed vessel is the steam boiler or some other source of steam supply.

Mr. Leilich gives a description and the data from tests of a 5,000 gal. plant being installed in an isolated fortification, where fuel is expensive and storage facilities limited. Diesel engines are used and the boilers for the distilling plant are fired with fuel oil. The specifications called for 5,000 gal. per day of twenty-four hours, and an average production of distilled water of 6 lb. for each 1,177 B.t.u. of total heat above 32 deg. fahr. contained in the steam supplied to the apparatus. Practically, this means operating at a six to one efficiency, 1,177 B.t.u. being the total heat of one pound of dry saturated steam at a pressure of 45 lb. gage; the minimum pressure allowed.

A diagrammatic arrangement of the piping is shown and the results of the tests are given in charted and tabular forms.—*Jour. Eng. Club of Baltimore,* June, 1916.

THE MEASUREMENT OF VISCOSITY AND A NEW FORM OF VISCOSIMETER

By H. C. HAYES,[1] SWARTHMORE, PA. and G. W. LEWIS,[2] SWARTHMORE, PA.

Non-Member Non-Member

In determining the lubricating properties of an oil, the viscosity test is considered of great value, since by means of this test a good oil can readily be distinguished from a poor one. It is therefore very important that the engineer be able to measure the viscosity of an oil and also the variation of viscosity with temperature.

The present paper, dealing with the measurement of viscosity, gives in part the results of a somewhat extended research on the lubricating properties of oils. It is to be followed by a paper giving the relation between the lubricating properties of oils and some easily measurable physical properties.

VISCOSITY

Matter in all states exhibits a gradual yielding to tangential forces which tend to change its form. This property is termed viscosity and may be defined quantitatively as tangential force per unit area divided by shear per unit time.

To gain a clear physical concept of this definition, consider a plane surface, Fig 1, of area S, parallel to and at a distance d from another large plane surface, and the intervening space filled with a liquid whose coefficient of viscosity is η. If a given force, F, acting on this plane, is applied to S, the surface will be dragged along and will finally attain a steady velocity, which denote by V. In accordance with the above definition, the relation between these various factors would then be

$$\eta = F/S \div V/d \text{ or } \eta = F \,.\, d \div S \,.\, V \qquad [1]$$

the value of η depending on the units in which these various factors are measured. If absolute values are desired, the factors on the right hand side of the equation are to be measured in C.G.S. units; but if relative values will suffice, as is the case in nearly all engineering work, they may be measured in any units.

It must be borne in mind that equation [1] is not true when the velocity V, is changing, for then only a part of the force F, is used to overcome viscosity, a part being used in giving accelerated motion. Under such conditions, another term must be added to this equation. The nature of this term is not difficult to see, for let equation [1] be written $F = \eta \,.\, S \,.\, V/d$. When there is accelerated motion, the force, F, will be divided into two parts, the part used to overcome viscosity and that used to give accelerated motion. Call these parts f_1 and f_2 respectively, then at any instant $F = f_1 + f_2$,

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SYNOPSIS

The measurement of viscosity, the property of matter by which it tends to yield gradually to tangential forces acting to change its form, is the subject of this paper. This measurement is of first importance in determining the lubricating properties of an oil.

The treatment of the subject is lucid. The paper first defines the *coefficient of viscosity* and then develops a working formula for determining this coefficient. It continues with a description, with illustrations, of the various types of meters for measuring viscosity now on the market. These include short capillary meters, in which the liquid to be tested is forced through the capillary and the viscosity determined in terms of the time occupied in the flow, and orifice meters, employing an orifice in place of the short capillary. The paper predicts the errors introduced by the various types, and verifies these predictions in the case of the two types mentioned above by comparing the temperature-viscosity curve given by these meters for a light and a medium lubricating oil, with the true curves as determined by a modification of the capillary method used by Poiseuille, who, with Girard, first measured viscosity with accuracy.

The paper shows that the short capillary types give results about 50 per cent, and the orifice types about 100 per cent too small, and that none of the meters heretofore in use gives accurate comparative results for two different oils or for the same oil at different temperatures. It states that the only viscosimeter on the market that can be expected to give accurate results is the Stormer instrument, which attempts to measure the viscosity in terms of the torque required to spin a disc within the liquid. This instrument is debarred, however, on account of the mechanical difficulties involved.

The authors then describe their own meter, which they claim embodies all the good points of the Stormer meter and none of the defects. In this meter the viscosity is measured in terms of the torque which a cylinder experiences when suspended within a rotating liquid.

The specimen of liquid to be tested is contained within a cylindrical chamber which is rotated uniformly by a motor. A cylinder is suspended within the specimen by a wire so that the axes of the rotating liquid and cylinder coincide. The specimen chamber is surrounded by an oil jacket in which a thermometer is suspended. The jacket oil may be brought to any desired temperature by a heating coil. The cover of the jacket chamber has a scale graduated in degrees or may be calibrated to read the viscosity in terms of a standard liquid directly through the deflection of a pointer.

The authors have thoroughly tested out the meter, and found that the results given agree to within one per cent with the true curves for the light and medium oils and can safely be used as a standard.

The advantages claimed for the meter are: The instrument can be calibrated to give direct readings of the viscosity; the oil is not handled during a complete test at various temperatures; the design of the instrument is such that the temperature of the specimen follows closely the temperature of the bath, so the data for the temperature vs. viscosity curve can be taken while the sample is cooling; the meter gives the viscosity of mixtures, such as paints, as well as for liquids that have been carefully filtered; there are no glass parts to break; the personal error is eliminated and the meter can be made self recording.

In the discussion which followed the presentation of the paper, and which is here published, there was some criticism of the new meter, in some of which the extreme accuracy of the instrument was questioned, and some of which was incited by the fact that the meter gives results in other than absolute units, and so adds another scale to the existing scales of viscosities. The questions raised in the discussion are all answered in complete form in the authors' closure.

Presented at the Spring Meeting of The American Society of Mechanical Engineers, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 5 cents to members, 10 cents to non-members.

where $f_1 = \eta \, . \, S \, . \, V/d$ and $f_2 = M \, . \, dV/dt$, where M is the mass that is being accelerated and dV/dt is the average change of velocity per second of this mass. The complete instantaneous equation thus becomes

$$F = \eta \, . \, SV/d + M \, . \, dV/dt \qquad [2]$$

and the viscosity cannot be found from this equation unless the last term can be evaluated, which is usually difficult and often impossible.

DEVELOPMENT OF A WORKING FORMULA

In most physical measurements, comparative values are more easily obtained than absolute values. As a result measurements are made in terms of some standard, the absolute value of which has been determined by a more or less laborious process. In making measurements of viscosity, the standard usually chosen is water at a temperature of 20 deg. cent.

Girard and Poiseuille, by studying the flow of liquids

Fig. 1 Conception of Viscosity

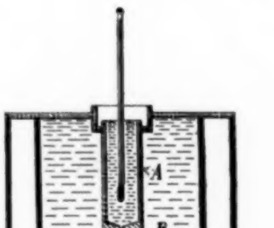


Fig. 2 Short Capillary Type Viscosimeter

through capillary tubes, were the first to measure the absolute value of viscosity with anything like accuracy. On the basis of his excellent experimental work on the viscosity of water, Poiseuille deduced the formula

$$V = K.D^4.H/L$$

where V = volume of liquid transpired
L = length of capillary
D = diameter of capillary
H = pressure
K = constant for each liquid at a given temperature.

Later, this empirical formula and its corrections were proved by several investigators.[1]

By assuming there is no slip at the surface of the capillary, that the liquid flows steadily without eddies or turbulent motion, and that there is no kinetic energy of efflux, then the transpiration formula for a liquid flowing under its own head becomes

$$\eta = \frac{\pi}{8} \, (hgr^4/lv) \, \rho t$$

where η = coefficient of viscosity (often contracted to viscosity)
h = liquid head
g = acceleration of gravity
r = radius of capillary
l = length of capillary
v = volume of flow
t = time of flow
ρ = density of liquid.

Experiment shows that the first assumption is true if the

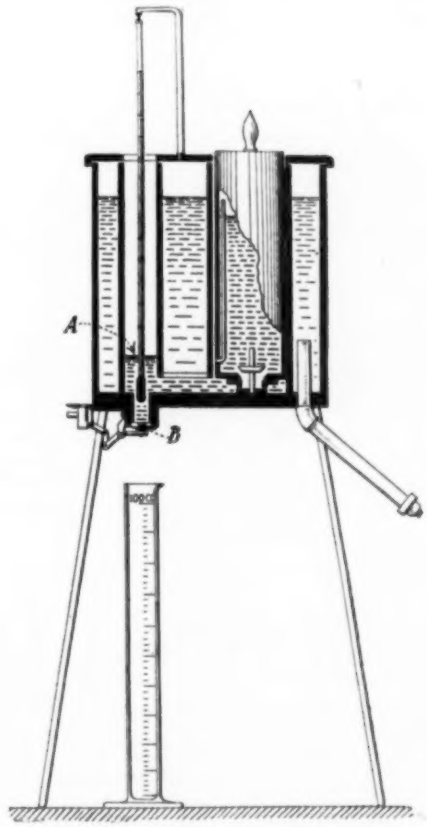


Fig. 3 Orifice Type Viscosimeter

liquid is one that wets the surface of the capillary. The work of Reynolds shows the second assumption is true if the velocity of the liquid through the capillary is kept less than $700 \, . \, \eta/\rho \, . \, r$ cm. per sec. The third assumption, of course, can never be true. The liquid must have kinetic energy when it leaves the capillary. In accordance with equation [2], a correction term must be added which, according to Couette, Finkener, and Wilberforce, should be $- \, v \, \rho/8\pi lt$. The complete expression for the viscosity is therefore of the form

$$\eta = \rho \; (A \, . \, t - B/t)$$

where A and B are constants for any piece of apparatus, ρ and t are the density and time of flow, respectively.

After a thorough examination of the recorded data on the viscosity of water, Knibbs concluded that the correct formula should be

$$\eta = \pi hgr^4\rho t/8 \, lv - 1.12v\rho/8\pi lt$$

It is to be noted that the correction term is larger than that

[1] Stokes, Trans. Camb. Phil. Soc., 1849, vol. 8, p. 287; Wiedmann, Poggendorf's Annalen, vol. 99, p. 177; Hagenoack, Pogg. Ann., vol. 109, p. 385; Stefan, Wien. Bar., vol. 46, p. 495; Couette, Ann. Chim. Phys., vol. 21, p. 433; Neumann, Vorträge über Hydrodynamik; Wilberforce, Phil. Mag., vol. 31, p. 407; Jacobson, Arch. f. Anat. u. Physiol., 1860, p. 80; Knibbs, J. Roy. Soc. N. S. W., vol. 29, p. 77; Boussinesq, Compt. Rend., vol. 110, p. 1160; Brillouin, La Viscosité (Gauthiér Villars, 1907.)

given by Couette. Moreover, this correction term varies with the time of flow, approaching zero when the velocity of flow is very slow, in which case t becomes very great. The value of the term increases with the temperature of the liquid since the time of flow decreases, and so the percentage of error in a viscosity vs. temperature curve due to neglecting this correction factor will increase abnormally toward the higher temperatures. This is due to two causes, the correction to be applied increases with the temperature and the value of the quantity to be corrected decreases rapidly with the temperature. Attention will be called to this fact when some of the various comparative methods are discussed. It is further to be noted that this correction term varies inversely as the length of the capillary. A short capillary requires a large correction term.

This formula, as corrected by Knibbs, has been submitted

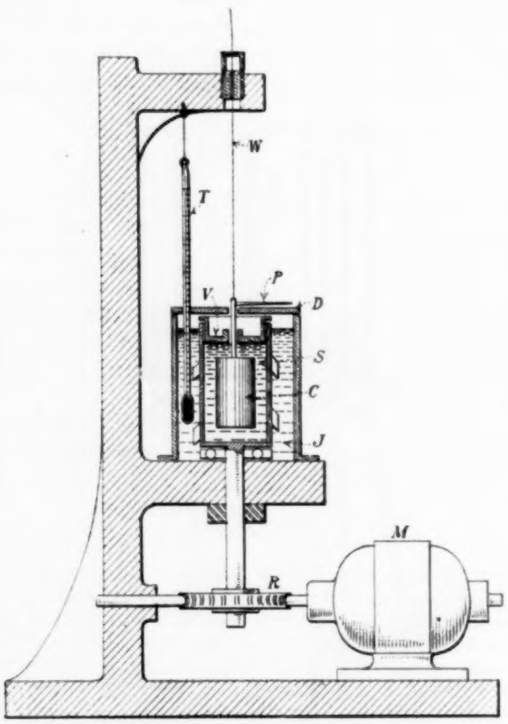


FIG. 4 THE NEW VISCOSIMETER

to careful experimental test by Hosking, and by Bingham and White. These investigators have determined the constants of the formula experimentally and have obtained fair agreement with theory. The capillary tube method, as employed by these experimenters, though complicated and laborious, can be depended upon for giving absolute values of the viscosity, and the accuracy of any viscosimeter can be determined by a comparison with the results obtained by this method.

CLASSIFICATION OF VISCOSIMETERS

Class 1. *Short Capillary.* In meters of this type, the liquid to be tested is forced either by gravity or by pressure through the capillary and the viscosity is determined in terms of the time required for a given volume to pass through the meter, as compared with the time required for a standard liquid to discharge the same volume.

A cross section of a meter of this type is shown in Fig. 2. The essential parts of the instrument are a cylindrical bowl, *A*, in which the oil is placed and a short capillary tube, *B*, through which it is discharged. The instrument must have temperature controlling and measuring devices, means for starting and stopping the flow and volume and time measuring apparatus.

To this class belong the Saybolt meter, adopted as a standard by the Standard Oil Co.; the Engler meter, adopted as a standard by the U. S. Government and Germany; the Redwood meter, adopted as a standard in England; the Scott meter; and the pipette, adopted as a standard by the Pennsylvania Railroad and much used by chemists. The majority of the viscosimeters on the market are of the short capillary type.

Class 2. *Orifice.* This type employs an orifice in place of the short capillary of the previous type. Fig. 3 is a section of such a meter, in the cylindrical bowl, *A*, of which the oil to be tested is kept at constant head above the orifice, *B*. The Carpenter meter belongs to this class.

Class 3. *Dropping a solid body through a tube filled with the liquid,* the solid body being usually a sphere or a plunger. Meters employing this principle determine the viscosity in terms of the time required for the body to drop a certain distance through the liquid, as compared with the time required

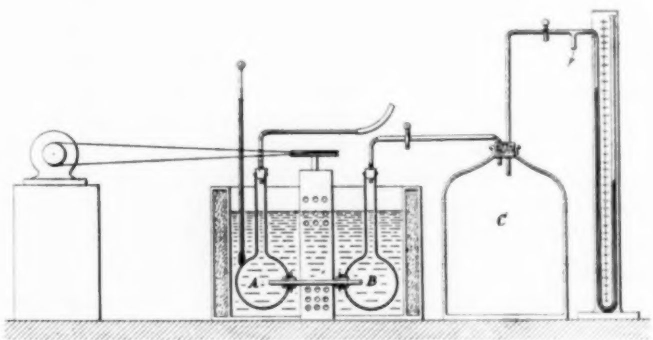


FIG. 5 CAPILLARY TUBE METHOD

for the same body to drop through a standard liquid. To this class of meters belong the Perkins meter, which employs a plunger and vertical tube, and the Flowers meter, which employs a small steel sphere and a slanting tube.

Class 4. *Oscillating Disk or Cylinder.* These meters determine the viscosity in terms of the damping which the oscillating disk or cylinder experiences when placed in the liquid as compared with the damping when placed in the standard liquid. The Doolittle meter is an example of this class.

Class 5. *Rotating Disk or Cylinder.* This type determines the viscosity in terms of the speed of rotation of the disk or cylinder in the liquid under test as compared with the speed of rotation in the standard, the driving torque remaining constant. The Stormer meter is an example of this class.

DISCUSSION OF THE VARIOUS TYPES

The paper here enters into a discussion of the value of each of the above types, so far as accuracy is concerned. It enumerates the following errors and indicates their causes and magnitudes:

Acceleration error. In all meters of *Classes* 1 and 2 the acceleration term ($M \,.\, dV/dt$) is neglected since its evaluation is impossible. This introduces an acceleration error.

Surface tension error introduced in all flow types due to difference in surface tension of the standard liquid and the liquid under test.

Critical velocity error. A source of error in most capillary and orifice forms is that the dimensions of the instrument are such that for the standard, water, the flow exceeds the critical velocity and the resultant turbulent flow makes the value of t abnormally large.

These three errors are prominent in all meters named above as standards and cause the viscosity as given by these meters to be much too low.

The constant speed of rotation which a disk or cylinder immersed in a liquid will attain under the action of a constant torque is a true measure of the viscosity of the liquid. The Stormer viscosimeter attempts to operate in accordance with this principle, but the friction of the moving parts is necessarily such that a constant torque cannot be obtained. With proper refinement, this meter could be made to give good results. The fact that a meter based on this principle can theoretically give accurate results has led to the development of a new viscosimeter now to be described.

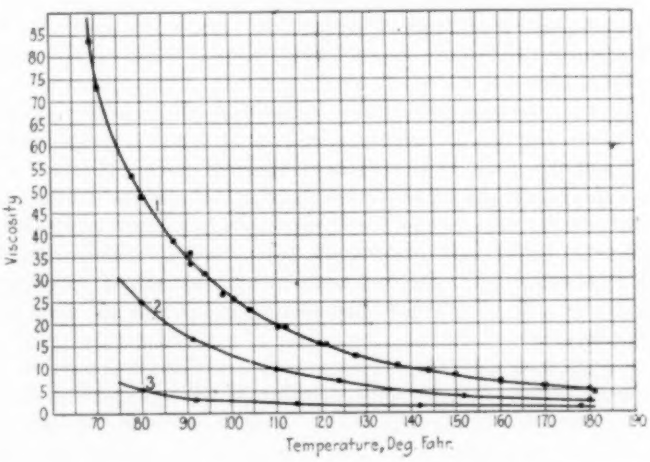


FIG. 6 VISCOSITY CURVES FOR MEDIUM GAS ENGINE OIL

THE NEW VISCOSIMETER

This viscosimeter operates in accordance with the principle that a solid body having a surface of revolution experiences, when suspended in a rotating liquid, a torque which is proportional to the viscosity of the liquid. The instrument is shown diagrammatically in Fig. 4. The specimen, S, is contained within a cylindrical chamber which is caused to rotate uniformly by a motor, M, through a worm drive, R. A cylinder, C, is suspended within the specimen by a thin steel wire, W, so that the axis of the rotating liquid coincides with the axis of the cylinder. The specimen chamber is provided with a cap, V, so shaped that the excess liquid can overflow when the cap is seated and thus give constant conditions within the chamber. The specimen chamber is surrounded by an oil jacket, J, in which a thermometer, T, is suspended. The jacket oil may be brought to any desired temperature by means of a heating coil, or a side coil not shown in the diagram. The cover, D, of the jacket chamber is provided with a scale which is marked in degrees or may be calibrated to read off directly, through the deflection of the pointer, P, the viscosity in terms of a standard liquid. The specimen chamber and the suspended cylinder are both made of copper to insure constant temperature throughout the specimen and the outside of the specimen chamber is provided with blades which keep the jacket oil thoroughly mixed as the chamber revolves and thereby exposes the latter to a uniform temperature. This is an important factor toward insuring constant temperature throughout the specimen.

The experimental work has shown that the temperature of the specimen is uniform to within a small fraction of a degree. Moreover, the temperature of the specimen follows the temperature of the jacket oil so closely that the temperature-viscosity curve can be taken while the temperature is slowly raised or lowered. This proves to be a great saving of time. It also saves labor, for one does not need to stand by the instrument continually. The deflection of the pointer is at any instant a measure of the viscosity, so all that is required is to take simultaneous readings of temperature and deflection at intervals during the heating or cooling process.

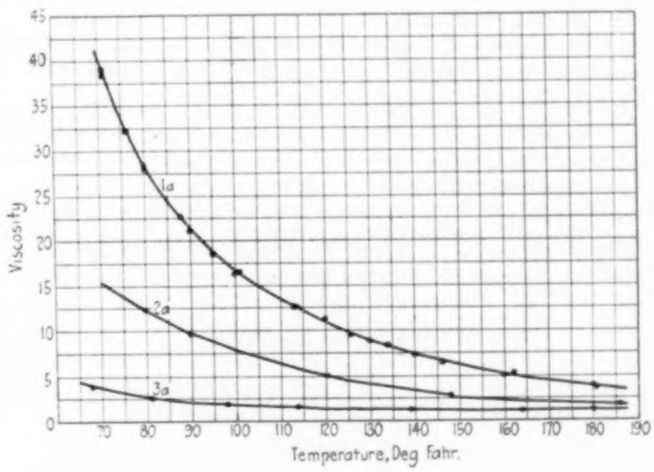


FIG. 7 VISCOSITY CURVES FOR LIGHT GAS ENGINE OIL

EXPERIMENTAL RESULTS

To test the accuracy of this viscosimeter, the temperature-viscosity curve was found for a light and a medium gas engine oil by the capillary tube method, the apparatus for which is shown in Fig. 5. The oil was drawn from vessel A to vessel B, and vice versa, by connecting each in turn with the partial vacuum chamber, C. These vessels were submerged in a thermostat which could be maintained at any desired temperature. The results, in terms of the viscosity of water at 20 deg. cent., are given by the points enclosed in circles for curves 1 and 1*a*, Figs. 6 and 7, the latter referring to the lighter oil. The viscosity of these same oils as given by the new meter is represented on curves 1 and 1*a* by the points enclosed in squares. The agreement between the two methods is almost perfect.

The viscosity of these oils as given by a meter of the short capillary type, Fig. 2, is given in curves 2 and 2*a*. Curves 3 and 3*a* give the viscosity of these oils as obtained with a meter of the orifice form, Fig. 3. As predicted, the results given by the short capillary type are much too low (on the oils tested about 100 per cent too low) and the results given by the orifice type are still lower.

CONCLUSIONS

The errors inherent in all flow types of viscosimeters have been predicted and the predictions verified by experiment. The magnitude of the errors are such that these meters cannot be depended on for giving even approximate results. The various meters of this type on the market do not give results which are in agreement, and no one of these meters can justly be claimed as a standard.

The new viscosimeter of the non-flow type described has the following advantages:

1 It gives values for the viscosity which are in agreement with those given by the standard capillary tube method.
2 During a series of tests at various temperatures, the oil is not handled.
3 The sensitiveness of the instrument can be made anything desired by changing the speed of rotation of the specimen or by using suspension wires of various diameters.
4 The density or change in density is not a factor in computing the results, in fact the instrument may be graduated to read off the viscosity directly.
5 The viscosity of liquids which contain particles in suspension can be measured, and the operation of the meter is independent of the color of the specimen.
6 The temperature-viscosity curve can be taken with a fair degree of accuracy while the temperature is rising or falling, as the temperature of the specimen follows the temperature of the jacket so closely.
7 The personal error which arises in determining time intervals with a stop watch is removed.
8 The instrument is simple, rigid and self-contained. It has no separate parts to get lost or glass parts to get broken.

DISCUSSION

MR. HERSCHEL CONSIDERS THERE IS NEED OF IMPROVED LONG CAPILLARY VISCOSIMETER

WINSLOW H. HERSCHEL (written): The authors practically admit that the long capillary viscosimeter is the most accurate instrument for determining viscosity. No objection can be raised against this method on grounds of accuracy, neither is it necessarily "complicated and laborious." Couette, who experimented with both the capillary and the concentric cylinder methods, regarded the capillary method as the more exact, and ascribed the error in the latter method to eccentricity. As far as can be determined from Fig. 4, I should judge that this error would be greater in the authors' instrument than in that of McMichael,[1] in which the shear in the liquid is mainly between the bottom of a suspended disk and the bottom of the revolving cup. I believe there is more need of improving old forms of instruments and methods of calculating viscosity than there is in devising new instruments. What is required is an improved, long capillary viscosimeter which is self-contained and portable; and the abandoning of such instruments, formulas and methods as lead to the expression of results in any other terms than of absolute viscosity. The revolving cup type of instrument may have a field of usefulness in commercial work, where quickness of determination is of more importance than extreme accuracy, but it is handicapped by its greater cost as compared with a capillary tube instrument.

MR. BINGHAM RAISES SOME POINTS OF CRITICISM

EUGENE C. BINGHAM[2] (written). The great misfortune of technical viscosity is that the results are not expressed in terms of absolute viscosity. Instead of this we have Engler degrees, Saybolt seconds, and many other units corresponding to the different types of instruments already suggested. The property, of interest in lubricating for example, can hardly be expected to be simply related to Engler degrees or any other arbitrary unit, even if it is simply related to viscosity. It is an advantage of the proposed instrument that it can be calibrated to read in terms of absolute viscosity, as is true of the McMichael instrument. It is the more unfortunate that the authors have expressed their results in other than absolute units.

It is also an advantage of this type of instrument that an accurate determination of the density does not have to be made before the absolute viscosity can be determined. The density undoubtedly affects the rate of flow in instruments of the Engler and Saybolt type, although the density is quite a distinct property from the viscosity. Unless the density is determined, the best that can be done is to calculate the viscosity divided by the density, i.e., the so-called *kinematic viscosity.*

The revolving cylinder and disk methods have been found to be less simple mathematically and less accurate experimentally than the capillary tube methods. Before the use of any one of these instruments becomes established, it should be shown that it will reproduce the absolute viscosity of liquids of widely different, but accurately known, viscosities. The error due to kinetic energy correction, eddy currents, lack of perfect centering, etc., should be carefully studied.

The tests which the authors have made are not convincing. They refer to the loss of pressure in giving kinetic energy to the liquid as the *error,* which is quite confusing. In instruments of the Engler and Saybolt types the times of flow are simply compared to the times of flow of water. Since these are arbitrary numbers there is no *error* due to acceleration. There *are* sources of error in these instruments amounting to two or more per cent, due to lack of perfect temperature control, etc., but that is quite different from the 100 per cent *error* mentioned. The authors use the term *error* as synonymous with what we may better term *kinetic energy correction.* Their Figs. 6 and 7 indicate the different values of the kinetic energy correction for different instruments, which would have been brought out clearly had they at some point in their paper expressed their results in terms of absolute viscosity. The fact that the curves for the capillary tube and the revolving cylinder are nearly identical would appear to mean that the kinetic energy corrections in both cases are nearly the same. It certainly does not prove that the kinetic energy correction is negligible in either case.

Instruments of this type have often been suggested for use with suspensions. Such use should be made with caution, since contrary to the statement in the paper, plastic substances do not "exhibit a gradual yielding to tangential forces" unless the tangential force exceeds a certain limit. Suspensions may be plastic, in which case the results with instruments of this type may not be interpretable on the ordinary assumptions.

The authors (Figs. 6 and 7) have made the common mistake of regarding *times of flow* as proportional to viscosity. It cannot be emphasized too strongly that this is not the case, although apparent authority for such a statement may be found again and again in the literature of the subject. It is rarely that the serious consequences of this erroneous assumption are so clearly apparent.

[1] Journal of Industrial and Engineering Chemistry, Nov. 1915.
[2] U. S. Bureau of Standards, Washington, D. C.

MR. PEABODY EMPHASIZES NEED FOR INTERNATIONAL STANDARD OF VISCOSITY

E. H. Peabody (written). The determination of the viscosity of oils used for fuel purposes is becoming a matter of increasing importance, owing to the rapidly growing use of the so-called mechanical atomizer. This type of oil burner sprays the oil by means of centrifugal force which is imparted to it by forcing the liquid through small passages tangential to a central chamber, from which it issues from an orifice the center of which usually coincides with the axis of rotation. Thus, the viscosity of the liquid has a very direct and important bearing on the satisfactory spraying of oil by this method, and usually the viscosity of the oil has to be reduced by heating. A knowledge of the temperature-viscosity properties of fuel oils is almost a necessity to the users of plants in which the mechanical atomizer is installed.

Any discussion of the matter of viscosity, therefore, is to be welcomed, and a paper which has apparently been prepared with so much care as this one, and which describes research work the result of which presents such a list of advantages as those given in the final paragraph of the paper, is a distinct addition to the art.

On the other hand, there will be little gain, at least in so far as the users of fuel oils are concerned, if the net result of the work of the authors is to impose upon the unsuspecting public still another and additional *scale of viscosities.* Thus, in Figs. 6 and 7, temperature-viscosity charts are given, and the horizontal scale is perfectly intelligible to ordinary minds; we all have a reasonable idea of temperature in degrees fahrenheit. But I would like to ask the authors what the vertical scale signifies, wherein the viscosity is given in figures ranging from 0 to 85. They call it *viscosity*—and the trouble now is that there are a score or so of different viscosity scales in use.

Almost any one of the instruments named by the authors, particularly those which have been adopted as standards by various interests (as the Saybolt, Engler, Redwood, etc.) would be entirely satisfactory if everybody used it. In other words, comparative values are about all we need, and as long as everybody bases his work on the same comparative values little trouble will result. If, however, different standards are used, each having its own individual meaning, great confusion will result,—and this, unfortunately, is the case with regard to viscosity. Thus, viscosity measured on the Saybolt scale is a very different thing from that measured on the Engler or Redwood, and it becomes necessary to specify whether the results are given in one or the other scale. Further, there appears to be no very definite way of making comparisons between the various scales, due, doubtless, to the very errors which the authors of this paper so clearly point out.

There is a crying need today of some international standard for the measurement of viscosity, and it is to be hoped that either this Society or some other will initiate some movement which will result in this very desirable agreement of all authorities.

In this connection, a very interesting suggestion will be found in the discussion of viscosity in a work entitled An Examination of Hydrocarbon Oils, translated from the German of Professor D. Holde by Dr. Edward Mueller, and published by John Wiley & Sons, 1915. In this book a formula devised by Ubbelohde is described, by which viscosity in degrees Engler may be reduced to *absolute viscosity.* The suggestion is made that the viscosity of liquids be reported in terms of the viscosity of water; in other words, that the absolute viscosity of water be taken as unity, and the absolute viscosity of other liquids (having been determined by the Engler instrument and corrected by Ubbelohde's formula, or by some other method) be reported in terms of these units as *specific viscosity.* This seems to indicate a very satisfactory solution of the matter, and is worthy of consideration as an international standard. Why would it not be quite as satisfactory to report absolute viscosity of liquids in terms of the absolute viscosity of water, exactly as we take water as a basis in *specific gravity, specific heat,* etc.?

I trust that the authors will describe more fully the meaning of their viscosity scale, and possibly point out a method of applying it to an international standard.

MR. HAYES REPLIES TO THE POINTS RAISED IN THE DISCUSSION

H. C. Hayes. In reply to Mr. Herschel, the authors do not "practically admit" that the long capillary method for determining viscosity is the most accurate. They simply claim this is the best absolute method for determining the viscosity of some standard liquid, but there are other methods, comparative methods, which determine the viscosity of an unknown liquid in terms of the viscosity of a standard liquid with less error than is introduced by the long capillary tube method in determining the viscosity of the standard liquid.

The long capillary tube method is certainly complicated and laborious. I have found from practice that several days are required to secure the data for a temperature-viscosity curve for a single oil. It must be remembered that the relation between the head and the tube dimensions must be such that the flow will never exceed the critical velocity, and this requires that the time of flow for the more viscous oils and for all oils at low temperatures will be abnormally great. Moreover, these capillary tubes are difficult to clean and hard to duplicate.

In regard to the McMichael instrument, the lines of flow above and below the disk are spirals, and not circles. This is due to the centrifugal action of the rotating liquid, and as a result an error is introduced, due to the fact that the liquid undergoes acceleration. This error is not great, but, such as it is, it is largely avoided in the Hayes-Lewis meter, where a cylinder is used instead of a disk. In this instrument the ends of the cylinder do not approach the top and bottom of the specimen chamber closely, and as a result most of the viscous forces are confined between the cylindrical surfaces of the cylinder and the chamber. The stream lines within this region are true circles and the liquid undergoes no acceleration, and as a result the small acceleration effect at the ends is negligible. This is one of the reasons for our using a cylinder instead of a disk.

For most engineering purposes the specific viscosity (absolute viscosity divided by absolute viscosity of water at 20 deg. cent.) will serve fully as well as the viscosity expressed in absolute units. The specific viscosity is readily transformed to absolute units whenever such units are required, and the calibration of viscosimeters is somewhat simplified by calling the viscosity of water unity.

Replying to Mr. Bingham, no claim has been made that the Hayes-Lewis viscosimeter is more simple than the long capillary tube as an absolute instrument. It certainly is less simple mathematically, but this fact does not prevent the instrument from giving excellent comparative results.

In regard to the reproduction of the absolute viscosity of liquids of widely different but accurately known viscosity, we

have attempted to do this. We have worked with water, light and medium oils, and glycerine. In each case the absolute value was obtained by the long capillary tube method in accordance with Knibb's formula:

$$\eta_1 = \pi h g r^4 \rho t / 8lv - 1.12 v\rho / 8\pi \eta_1 lt$$

where the meaning of the various letters is in accordance with Par. 8 of the paper. The coefficient of water at 20 deg. cent. so obtained was within 0.5 per cent of the value obtained by Hosking, and we have assumed the values obtained for the oils and the glycerine by this same method were of the same degree of accuracy. The values so obtained were in each case divided by the value obtained for water. In the case of the oils these values are plotted as dots in curves 1 and 1*a*, Figs. 7 and 8. Then the deflection given by our meter when water at 20 deg. cent. was placed in the specimen chamber was taken by means of a mirror, attached to the pointer, and telescope and scale. This angle was divided into the deflection angle given by the oils and glycerine. These values are plotted as squares on the same curves. The curves show almost perfect agreement between the two methods for the oils at various temperatures. The agreement in the case of glycerine was not quite as good, the greatest variation being 2 per cent. We were several days in securing these results and attributed this variation to the absorption of moisture by the glycerine. All told, it seems these results are convincing.

It is to be noticed that all kinetic energy corrections were made in determining the absolute viscosities in accordance with Knibb's formula, and as the results given by our meter are in good agreement, the work does prove that the kinetic energy correction is negligible despite Mr. Bingham's statement to the contrary.

Lack of perfect centering and small variation in height adjustment of the cylinder cause little or no error, for the reason that the viscous forces are inversely proportional to the thickness of the oil between the cylinder and container. The gain in viscous forces on one side of the cylinder, due to imperfect centering, is largely offset by the loss on the opposite side, and this is also true for vertical displacement, providing the displacement or lack of perfect centering is not great.

The authors have not claimed an error of 100 per cent or any other figure for the Engler or the Saybolt instruments when they are merely used to obtain Engler degrees or Saybolt seconds respectively. Their paper, as the name suggests, deals with the measurement of viscosity. And when, as is usually done when viscosity is determined with these instruments the formula $\eta_x = \rho_x t_x t_w$ is used for computing the viscosity, the 100 per cent error mentioned will be given. This error is due to the kinetic energy correction which is not corrected for and which is quite confusing. It is true that Ubbelohde's formula is useful in making this correction for the Engler instrument, and the recent work done by the U. S. Bureau of Standards giving the relation between the Engler and Saybolt instruments makes possible the correcting of the Saybolt instrument readings. Even if Ubbelohde's formula were correct (and it is only claimed to be approximate) still corrections that must be made in this roundabout way are confusing. There is great need for an instrument that gives results which require no correcting when absolute values of viscosities are required, and which gives at all times readings proportional to the absolute values.

Suspensions made of tempered steel may be plastic if the tangential forces brought into play exceed the elastic limit, but there is no reason why such forces should be brought into play. In fact, our instrument is so constructed that the suspension cannot be twisted beyond this limit.

A close reading of the paper will convince anyone that the authors have not made the mistake of regarding time of flow as proportional to viscosity. Our curves show clearly the serious consequences of this erroneous assumption, and we have regarded this as the chief value of our paper.

In reply to Mr. Peabody, we did not intend to impose on the unsuspecting public another meaningless viscosity scale. In fact, when trying to interpret the results given by various meters we have found the same confusion that he has apparently found. We have also felt the need of some standard unit to which all readings should be reduced, and we decided that the best unit would be that of water at 20 deg. cent. (the same as Mr. Peabody has suggested). The ordinates of our curves are given as the values of the absolute viscosity of the oils divided by the absolute values of the viscosity of water at 20 deg. cent. It was due to an oversight that the ordinates were not labeled "specific viscosity" instead of "viscosity," but the paper states what the ordinates are.

Electric operation of freight trains has been introduced on the Shilden-Newport branch of the North Eastern Railway in England. Locomotives of 74 tons weight are used, direct current at 1500 volts being supplied from an overhead catenary system.—*Electric Railway Journal*, July 1, 1916.

Some interesting details of the making of paper from bagasse at the Preston Central, Cuba, are given in the Bulletin of the Canadian Department of Trade and Commerce. Ten months ago, as an experiment, this Cuban factory started a department for the manufacture of wrapping paper from the by-products of their cane mill. The venture has proved successful and arrangements are being made for the manufacture of all grades of paper. The present daily output is four tons. Three weights of wrapping paper are made, of which the highest is 80 lb., and it is claimed that this paper made from cane pulp is equal to, if not slightly better than that manufactured from imported kraft stock, while it can be produced and marketed at a considerably lower price.—*The International Sugar Journal*, June 1916.

Advocating the adoption of some generally intelligible and convenient unit of viscosity measurement, whose use would radically improve a state of affairs where few know how to translate the results which they obtain into results comparable with those obtained with another instrument, Parker C. McIlhiney states that it has been suggested that the unit of viscosity expressed in C. G. S. units be called the "poise" in honor of Poiseuille, but the suggestion has not been adopted generally and it is customary to speak of the "absolute" viscosity of a liquid.

The study of this important physical property of liquids has been seriously hampered by the lack of any kind of uniformity in its measurement, and if the "poise" be adopted as the name of the absolute unit, use might be made of the decimal multiple and submultiples of this unit, and then the centipoise—1 *cp.* = 0.01 *p.*—would be almost exactly the viscosity of water at 20 deg. cent. or 68 deg. fahr. Thus for all practical purposes in the lubricating oil business, it would be sufficiently near the truth to say that the viscosity expressed in centipoises is the specific viscosity, that is, the viscosity as compared with water at 20 deg. cent. or 68 deg. fahr.—*The Jour. Ind. and Eng. Chem.*, May, 1916.

BOILER SETTINGS FOR SMOKELESS COMBUSTION

Including the Latest Form of Double Arch Bridge Wall Furnace Now Used by the Chicago Smoke Department for Burning High Volatile Fuels

BY OSBORN MONNETT,[1] CHICAGO, ILL.

ONE of the old ideas with respect to smokeless furnaces was that if the fire were surrounded with a mass of fire brick, thereby keeping the flames away from the boiler heating surface, complete combustion and smokeless operation would be accomplished. Following out this idea a number of furnaces were installed along this line in the early days of the present Chicago Smoke Department. The first construction adopted was known as the full extension dutch oven setting, as shown in Fig. 1. This setting was extravagant of floor space and also necessitated setting the boiler high in order to get the heavy fire brick arch under the shell. It was expensive to install and to maintain.

DUTCH OVEN SETTINGS

In order to meet the objections of engineers and architects the setting was finally modified into a semi-extension setting as shown in Fig. 2, and later to the flush front setting, Fig. 3 None of these settings obviated the criticism of expensive head-room, nor did they remedy the difficulty of high maintenance charges.

Experience with these settings showed that the idea of surrounding a fire with fire brick for the purpose of smoke elimination was a fallacy. It developed in the course of the experiments that the intense radiation from the red hot fire brick had the effect of distilling the volatile matter off from the fresh coal more rapidly than would be the case with the old plain settings. When high volatile coal is thrown onto a fire there is a certain amount of volatile distillation, due to the temperature. We will call this the normal rate of distillation.

On the other hand, when coal is thrown into a dutch oven furnace there is a distillation effect in addition to that caused by the heat of the fire itself, due to the radiation from the fire brick arch. This produces a double distillation, which causes the volatile gases to pass away from the furnace so rapidly that it is difficult to prevent smoking.

DEVELOPMENT OF HAND-FIRED FURNACES

In the effort to develop a hand-fired smokeless furnace for return tubular boilers it was therefore necessary to take steps to reduce the rapidity of volatile distillation, bringing this down to a point which could be taken care of by the furnace. Following along this line, the old flush front dutch oven, as shown in Fig. 3, was modified by removing the fire brick arch from over the fire. This had the effect of increasing the economy and capacity of the setting as it took advantage of the direct radiation of the heat from fire to shell. It still provided a high temperature zone over and back of the bridge wall through which the gases had to travel, and then broke them up with a bulkhead and fire brick deflection arch in the combustion chamber. This construction, properly operated, was successful as far as the elimination of smoke was concerned. It was not, however, a commercial proposition as it then stood. The setting was rather high, expensive to install and maintain, and required buck stays in the side walls to take up the spring of the main arch. It was necessary to commercialize this setting, making it cheaper to install and to maintain, and reduce the head room required for its installation.

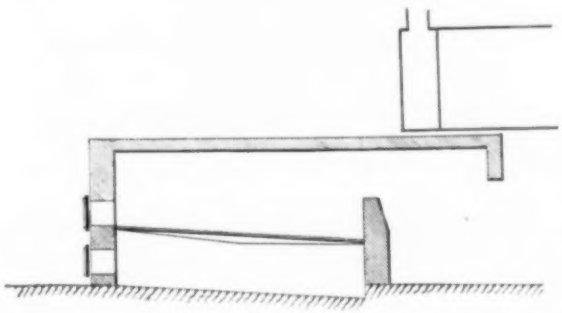


FIG. 1 FULL EXTENSION DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

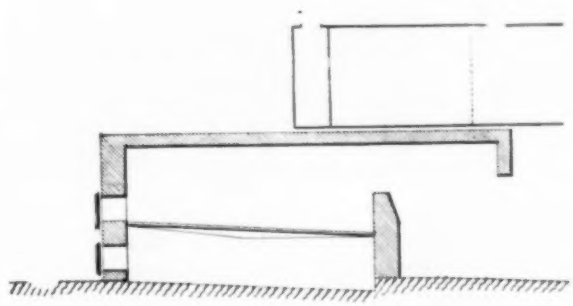


FIG. 2 SEMI-EXTENSION DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

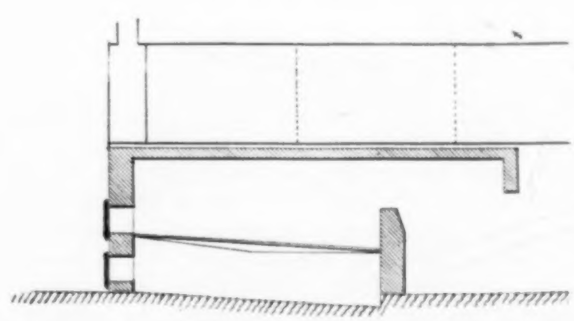


FIG. 3 FLUSH FRONT DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

[1] Engineer, American Radiator Co.

Presented at the Cincinnati local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, October 21, 1915.

The construction finally worked out to meet the requirements is shown in Fig. 5. This is known as the double arch bridge wall setting, as now used by the Chicago Smoke Department. It consists of a plain grate with the shell of the boiler completely exposed to the heat of the fire and a high temperature zone over the bridge wall, built with a butterfly arch construction in two spans, this construction being adopted because it is cheaper and easier to install and repair; also it does not impose so much stress on the side walls. Following the butterfly arch is a single span deflection arch with a fire brick bulkhead above, the bulkhead following the curvature of the boiler.

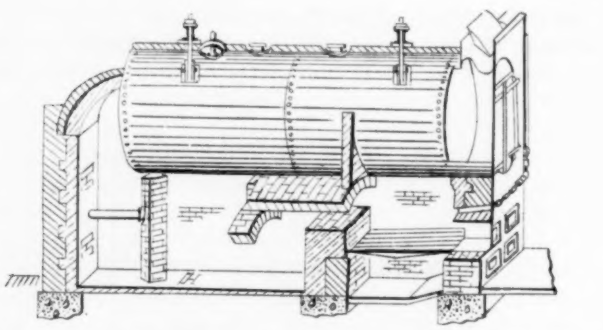


FIG. 4 SINGLE ARCH BRIDGE WALL FURNACE WITH SINGLE SPAN DEFLECTOR ARCH

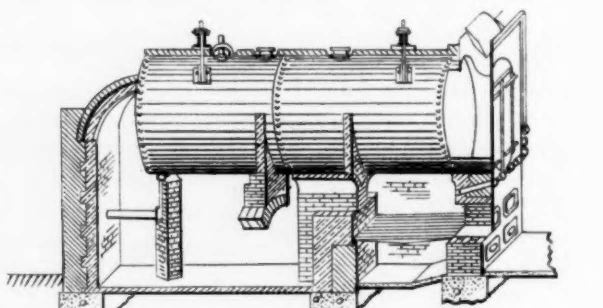


FIG. 5 PERSPECTIVE VIEW OF DOUBLE ARCH BRIDGE WALL SETTING FOR 2-COURSE BOILER

FIRING METHODS

The operation of the furnace then is as follows: When the fire is replenished by the alternate method of firing, the volatile matter distilling away from the fire passes back through the red hot tunnel of fire brick in which it is maintained at ignition temperature and where it mixes with the auxiliary air admitted through the air siphon steam jets and panel doors provided with the setting. In the combustion chamber this mixture of gas and air impinges against the bulkhead wall and passes under the deflection arch, being thoroughly mixed. Thus the conditions necessary for complete combustion are realized, namely, high temperature, which is obtained in the zone over the bridge wall; oxygen obtained by supplying auxiliary air and mixture of the gases. In such a setting it is possible to observe a secondary combustion taking place under the deflection arch, this combustion being as clean as a flame from a Bunsen burner.

The ordinary hand-operated air siphon steam jets as specified with this setting are shown in Fig. 6; while another type of steam jet, especially designed for a low setting, is shown in Fig. 7. Complete data for the installation of this furnace on all sizes of return tubular boilers are appended in Table 1, included in Fig. 8.

One of the old fallacies exploded by this setting was the idea that it is necessary to set return tubular boilers very high over the grates in order to get economical operation. It has been found that 36 in. from dead plate to shell is ample to get good combustion conditions with a 72-in. boiler. The areas through such a furnace, however, must be worked out carefully in order to insure success and not spoil the draft. The combined free area through the butterfly arches should be not less than 25 per cent of the grate surface. The free area between the bridge wall and the deflection arch should be not less than 40 per cent of the grate surface, while 50 per cent of the grate surface should be allowed under the deflection arch; if it is found impossible to get such area through this part of the setting with the combustion chamber on a level with the floor line, it is permissible to excavate the floor of the combustion chamber to any depth desired. The combustion chamber should be paved with second grade fire brick on edge.

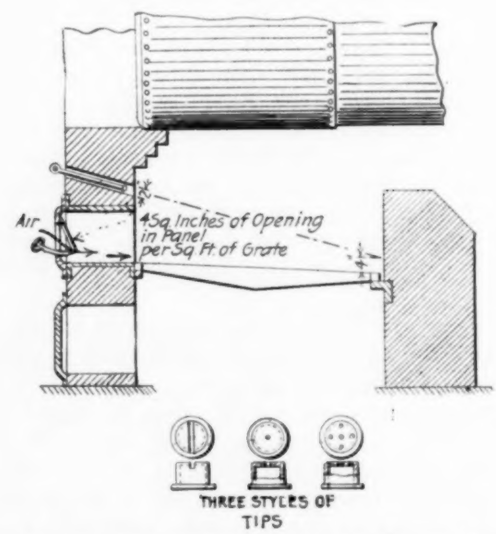


FIG. 6. DETAILS OF STEAM JET AND PANEL DOORS

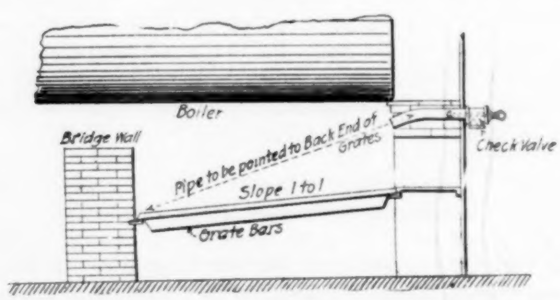
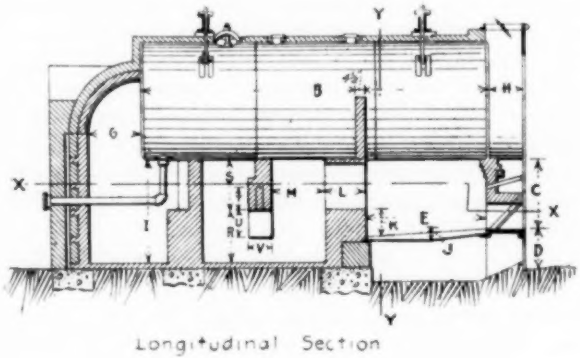


FIG. 7. CINCINNATI STEAM JET FOR LOW SETTINGS

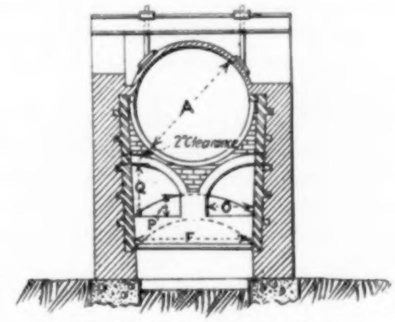
While the alternate method of firing has shown the best success, there are other points which should be observed to get the best results with such a setting. It has been found that the thick, heavy method of firing will make less smoke than the thin, spreading method. This would seem to be contrary to the old accepted ideas, but a few moments' consideration will show how this works out.

If two shovelfuls of coal are spread evenly over a clean, bright fire, all of the volatile matter in the coal is immediately

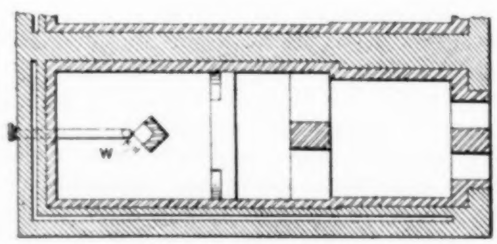
subjected to the intense heat of the fire and distilled off, making a great deal of smoke; if, on the contrary, the fire is replenished with six, eight and ten shovelfuls on one side, beginning at the bridge wall and filling up the low spots all the way to the front, it will be found that the rate of volatile distillation, and consequent smoke formation, is considerably less than in the first instance. The heat of the fire must penetrate the mass of coal more slowly, forming a film of ignited coal on top through which the gases must pass on their way to the furnace, causing an action somewhat akin to that of an underfeed stoker.



Longitudinal Section



Front Section Through Y-Y



Plan Section Through X-X

TABLE 1 - DIMENSION SHEET FOR DOUBLE ARCH BRIDGE WALL FURNACE

A	B	C	D	E	F	G	H	I	J	K	L	M	O	P	Q	R	S	T	U	V	W
42	12'0"	28	19	42	42	22	16	42½	3½	16½	18	21	18½	9	15	27½	15	9	8	13½	8
42	14'0"	28	19	42	42	22	16	44	4	15	18	24	16½	11	17	27	17	9	8	13½	8
48	12'0"	30	20	42	48	24	18	45½	3½	18	18	20	19½	7½	15½	30	15½	9	8	13½	8
48	14'0"	30	20	48	48	24	18	45½	4	16½	18	24	19½	9½	11½	28	17½	9	8	13½	8
48	16'0"	30	20	54	48	24	18	49½	4½	15	18	26	19½	11½	19½	30	19½	9	8	13½	8
54	14'0"	32	22	48	54	24	18	49½	4	16½	18	24	20½	11½	18	30	19½	9	9	13½	8
54	16'0"	32	22	54	54	24	18	51½	4½	15½	18	24	20½	13½	20	30	21½	9	9	13½	8
60	16'0"	34	22	60	60	26	18	55½	5	17	22½	26	23½	19	22½	33½	22	9	10	13½	8
60	16'0"	34	22	66	60	26	18	60½	5½	15½	22½	26	23½	15	24½	30½	24	9	10	13½	8
66	16'0"	34	24	60	66	28	18	54½	5	12½	22½	28	26½	11½	22½	34	20½	9	11	13½	8
66	18'0"	34	24	66	66	28	18	59	5½	17	22½	28	26½	13½	24½	36½	22½	9	11	11½	8
72	16'0"	36	24	66	72	30	20	59½	5½	18½	22½	30	29½	11½	24½	37	22½	9	12	13½	8
72	18'0"	36	24	72	72	30	20	60½	6	17½	22½	30	29½	13½	26½	40	24½	9	12	13½	8
72	18'0"	38	26	72	78	32	21	65	6	19	26	32	30	15½	27½	40	25	9	12	13½	8
78	20'0"	38	26	78	78	32	21	70	6½	11½	26	30	30	11½	29½	43	27	9	12	13½	8
84	19'0"	38	26	72	84	32	21	64	6	20	26	36	33	14	27½	40	24	9	12	13½	8
84	20'0"	38	26	78	84	32	21	69	6½	18½	26	36	33	16	29½	43	26	9	12	13½	8

Dimensions in inches, except as otherwise noted

FIG. 8 DOUBLE ARCH BRIDGE WALL SETTING DIMENSIONS

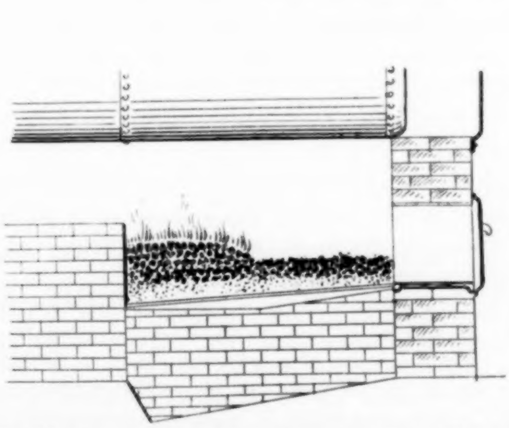


FIG. 9 METHOD OF STARTING FIRE, IGNITING FUEL FROM THE TOP

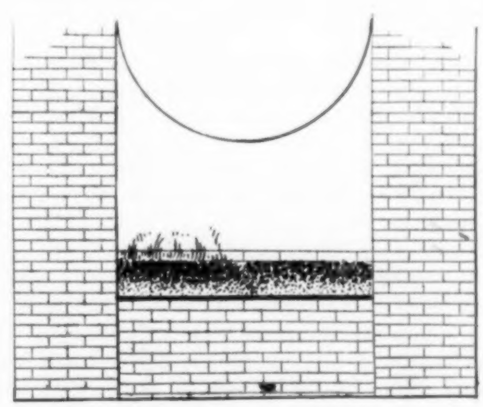


FIG. 10 CLEANING FIRES, WINGING OVER LIVE COALS ON TOP OF FRESH FUEL

BUILDING AND CLEANING FIRES

Building and cleaning fires also must receive careful attention where it is necessary to keep the smoke down on hand-fired units. The method of building a fire without making dense smoke is illustrated in Fig. 9. A layer of fresh coal is thrown on the clean grates to a depth of about 4 in. and some red-hot coals are thrown into the furnace at the bridge wall, or a fire of clean kindling is built at this point. Ignition then takes place from the top downwards. The coal in front gradually becomes ignited and the volatile matter passing off from this part of the furnace has to pass over the hot fire at the bridge wall. As a result, it is possible to get steam on the boiler without making dense smoke, by making liberal use of the panel doors to supply the necessary air for combustion.

In cleaning fires the same principle is used: Pull out one side of the fire, cleaning the grates, and then onto the clean grates throw a layer of fresh coal, quickly wing over red hot coal from the other side and allow the cleaned side to ignite from the top, as previously described. When this side has become well ignited and built up, the other side may be cleaned in the same manner. (See Fig. 10.)

HEATING LOADS

Many attempts have been made to design furnaces that would run at low rates of combustion such as on heating loads, without making dense smoke. None of the foregoing settings have been successful with this kind of load, owing to the fact that for success they all depend upon the maintenance of some form of brick work at a high temperature. When running at a low rate of combustion it is not possible to get the high temperature necessary to keep the fire brick construction hot; therefore these furnaces were not successful in reducing smoke at rates of combustion lower than 15 lb. per sq. ft. of grate surface per hour.

The type of furnace which has finally become standard for this class of service is a modification of the old down-draft principle (Fig. 11) formerly used for high-pressure purposes. The success of the down-draft principle as far as smoke performance goes depends on the frequency with which the fuel bed is disturbed. In high-pressure work where the rate of combustion frequently exceeded 25 lb. per sq. ft. of grate surface per hour, it was necessary to disturb the fuel bed at frequent intervals, sometimes so often as to slice green coal down through the water grates.

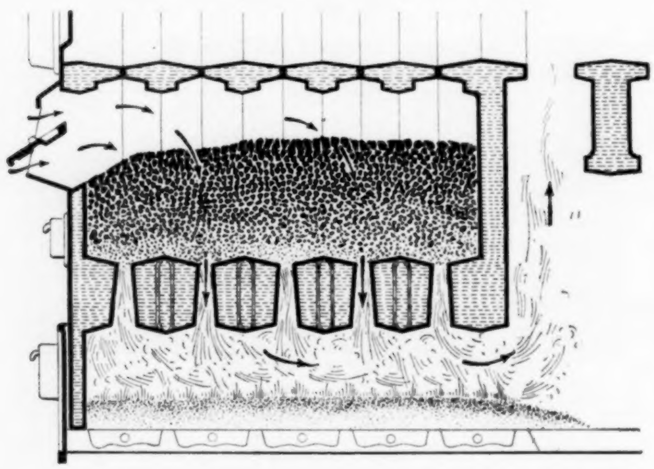


FIG 11 SHOWING THE DOWN DRAFT PRINCIPLE AS ADAPTED TO LOW RATES OF COMBUSTION

On the other hand for rates of combustion of not over 10 lb. per sq. ft. per hour, it has been found that this principle of burning is remarkably successful. Under low rates of combustion it is possible to run for long periods during which the fire is not disturbed, and during this time there is accumulating on the water grates a mass of coked coal which has gradually given up all of its volatile matter. When it becomes necessary to slice such a fire this supply of coked coal is all that falls to the bottom grate and no smoke is produced At the same time the volatile matter distilling from the coal has to pass down through the zone of high temperature thus insuring igniting temperature to the gases.

Another reason why this principle has been so successful on low rates of combustion is on account of the very efficient evaporative power of the water grates at these low rates. An ordinary plain grate boiler burning coal at very low rates of combustion drops its capacity to a point which is practically negligible; while the down-draft furnace will simmer along on a heating load at a very low rate of combustion and still make in the water grates themselves all the steam demanded.

The relative importance of water power as referred to transportation, dependent upon its cost and on that of competing steam power, is treated in a paper by L. B. Stillwell, presented at the 1916, Washington, D. C., meeting of the A.I.E.E.

Among the important points brought out by the author are the proportion which the cost of fuel for locomotives in the country as a whole, in various sections, and in the case of a number of different railroads, bears to the total cost of operation; the effect upon water power values of recent progress in the production of electric power, and power and transportation development on navigable streams.

Illustrations are given showing the limit of investment in developing a water power, as fixed by the cost of steam power in competition with it.

Railroad and canal operation are compared in the matter of power consumption for their respective speeds.—*Proc. A.I.E.E.*, XXXV-5.

With a reduction in its smoke production to an extent which the chief of the Bureau of Smoke Regulations places at 75 per cent, Pittsburgh is fast losing one of its distinctive titles.

The permissive density limit is less than No. 3 on the Ringleman smoke chart, while for densities equal to or above that value certain time limits are set beyond which the emission at such densities is prohibited.

This desired condition has not been reached without considerable expense nor without that harmony and accord between the industries and the smoke authorities, without which such ordinances usually remain dead letters. This coöperation is shown, in the case of the railroads, in the local use on their locomotives of coal of a lower volatility, and in the manufacturing plants by the use of appliances and methods better suited to the accomplishment of the desired end.

Encouraging progress seems to have been made in the abatement of the smoke nuisance in the Boston district, according to the annual report of the Board of Gas and Electric Light Commissioners of Massachusetts for the year 1915.

Fuel values per unit of cost, as investigated by Dr. J. H. Paterson, is the subject of a paper presented at the meeting of the Newcastle (England) section of the Society of Chemical Industry, held December 15, 1915.

The financial value to the consumer of a fuel must be measured by the amount of heat which can be obtained from that fuel by the expenditure of a definite amount of money. This value is totally distinct from, and is not affected by, the quantity of available heat which is utilized in any given process.

To meet the difficulty encountered in dealing with fuels of different classes the author makes the common unit of value the number of B.t.u. obtainable for a penny after there have been added to the price per ton all the costs of handling the fuel and causing it to burn. This he calls the absolute heat value of the fuel in question.

While very generally recognized that the less paid for coal the more incombustible matter (water and ash) it is liable to contain, it is by no means realized that the absolute heat value increases rapidly as the price decreases.

In tabular form the author compares some ten classes of fuels ranging, on the absolute heat value basis, from 200,000 B.t.u. down to 20,000 B.t.u.—*Jour. Soc. Chem. Ind.*, XXXV-1.

HIGH TEMPERATURE INSULATION

A Review of the Requirements of the Problem, and a Description of a New High Temperature Insulating Material, with Applications

By P. A. BOECK,[1] CHICAGO, ILL.

THE value and importance of efficient insulation for the prevention of thermal losses are shown in the extent of the investigation and research which have been devoted to that factor in the conservation of heat, but it was not until the comparatively recent introduction of the heat balance sheet that the various causes of heat losses and the reasons for their existence were brought to light.

Heat is a form of energy consisting of molecular vibrations of a periodic character and subject to the general laws of wave motion. It can be reflected, refracted and dispersed by creating the proper conditions. In other words, by the proper mechanical manipulation we can increase or decrease, within certain limits, the amount or rate of heat flow. One of the most common ways of doing this is by introducing alternate layers of materials having different heat-transmitting values, thus breaking up or changing the wave length. The introduction of air cells or voids within the body is a most effective method of accomplishing the reduction of the conductivity, though large voids have the effect of propagating heat by convection and radiation. The density of a body may be taken as an approximate criterion of its heat conducting capacity.

Heat is a form of energy consisting of molecular vibrations ferent methods, conduction, radiation and convection:

Conduction is the action taking place in the transfer of heat in which the heat energy is passed along from a particle at a higher temperature to one at a lower temperature by virtue of their contact. While this method of heat transfer applies to the three states of matter, it is of magnitude only in solids.

Radiation.—By radiation heat is transferred from one body to another without any material agency by wave motion; this applies only to the gaseous state of matter.

Convection is that process of heat transfer in which some portion of the body whose temperature is raised moves to another place in the medium where the temperature is lower, tending to raise the temperature of the medium. This method of heat transfer is therefore limited to liquids and gases.

Applying these methods to a steam boiler, the heat generated by the fuel burning in the firebox is imparted to the dry surface of the boiler plate by radiation from the hot fuel bed, furnace walls and luminous flames, and secondly from the moving gaseous products of combustion by convection. From the dry surface it travels through the soot, metal and scale to the wet surface purely by conduction and is in turn transmitted into the boiler water mainly by convection.

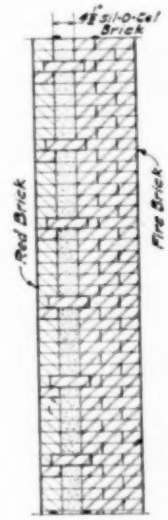


Fig. 1

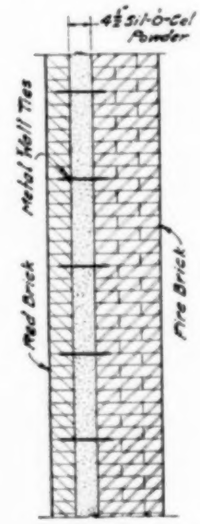


Fig. 2

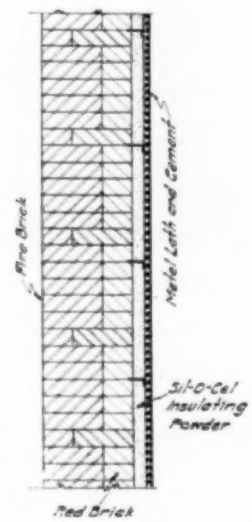


Fig. 3

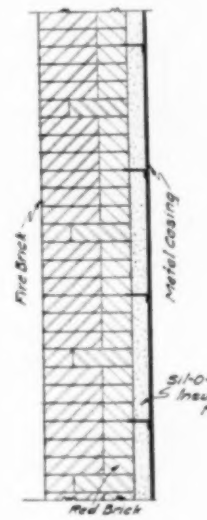


Fig. 4

Fig. 1 Boiler Setting Wall Insulated with Sil-o-cel Brick

Fig. 2 Boiler Setting Wall Insulated with Sil-o-cel Powder

Fig. 3 Typical Wall Construction Showing Sil-o-cel Powder Supported by Metal Lath Cement Finish

Fig. 4 Insulating Powder Between Wall and Metal Casing

That portion of the heat which is transferred to the walls of the furnace setting by any of the three methods mentioned is conducted through the setting and lost by radiation or convection from the outer surface of the setting, if means are not provided to prevent. It is the heat lost in this manner and methods for its prevention that will be especially considered.

RATE OF HEAT FLOW

The amount of heat conducted through a unit area from one part of the body to another is proportional to the difference in temperature of the two parts; directly proportional to the

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Abstract of paper presented at the Chicago local section of The American Society of Mechanical Engineers, January 14, 1916.

thermal conductivity of the body through which the heat passes and inversely proportional to the distance between the two parts of the body. In other words, the conduction of heat through a solid body from one place to another is a direct function of the conductivity of the body and the difference in temperature of the two planes, and an indirect function of their distances apart. This is identical with Ohm's law for transfer of electrical energy.

The heat transferred from one body to another by radiation is proportional to the difference of the fourth powers of the absolute temperatures of the two bodies. While this is strictly true only of the ideal "black-bodies," the variation is so small that, for all practical purposes, this relation holds good in ordinary procedure.

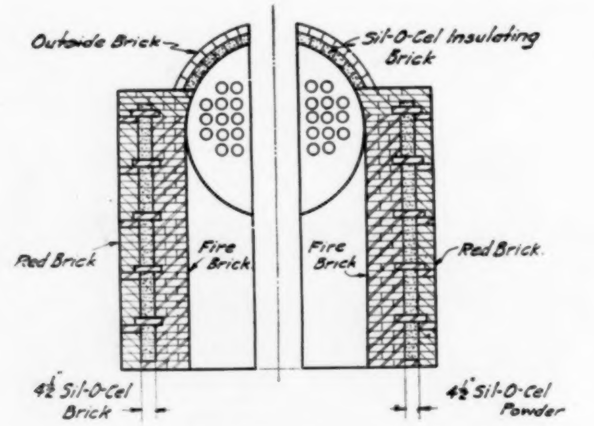


FIG. 5 METHOD OF INSULATING BOILER SETTING WALLS WITH SIL-O-CEL BRICK AND POWDER

This relation indicates why a hollow-wall space is an effective insulator in low-temperature work, such as refrigeration, etc., whereas in high-temperature operations the loss of heat by radiation through a hollow-wall space is so great that its insulating effect is less than if this wall space were filled with material of rather high thermal conductivity. This is especially true if the air space in the hollow wall is near the furnace side and becomes highly heated. This is entirely contradictory of the general belief that, since air is a poor conductor of heat, air spaces built into the walls of a furnace will greatly reduce heat loss by radiation. While the heat does travel very slowly through the air by conduction, it leaps over the air space readily by radiation, because the quantity of heat which passes across the hollow space is a function of the fourth power of the absolute temperature of the surfaces enclosing it, which loss is enormously increased by rise in temperature.

FURNACE WALLS

In general, in high-temperature furnace construction, there are two separate and distinct factors which must be considered to produce an effective wall.

The first of these is to provide a material having the ability to resist the action of high temperatures, sufficient mechanical strength and, possibly, the property of resisting corrosive slags, gases, etc., without spalling or being eroded.

The second is to prevent the excessive loss of heat due to conduction from the interior of the furnace to the outside where it is lost by radiation or conduction.

It is rare that a good refractory material is an insulator; usually it is necessary to augment or back up the refractory with some material having a much lower heat conducting capacity. Fig. 7 is a graphic presentation of heat transfers with and without such application.

The quantity of heat, H, in B.t.u. per hr. per sq. ft. conducted between two surfaces of a wall is

$$H = \frac{1}{\frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2} + + \cdots} \times (t_2 - t_3)$$

where d, d_1, d_2 = thickness in in. of component layers of wall. c, c_1, c_2 = thermal conductivities in B.t.u. per sq. ft. per in. thickness per hr. per 1 deg. difference in temperature at the average temperature of the component layers of wall, and t_2 and t_3 = surface temperatures of the respective sides of the wall in deg. fahr.

Fig. 7 is a graphic presentation of the heat loss through insulated and uninsulated walls; respectively 289 and 639 B.t.u. per sq. ft. per hr.

REQUIREMENTS OF FURNACE INSULATORS

The requirements of the insulating backing for the more refractory linings of furnaces are rather severe, and although

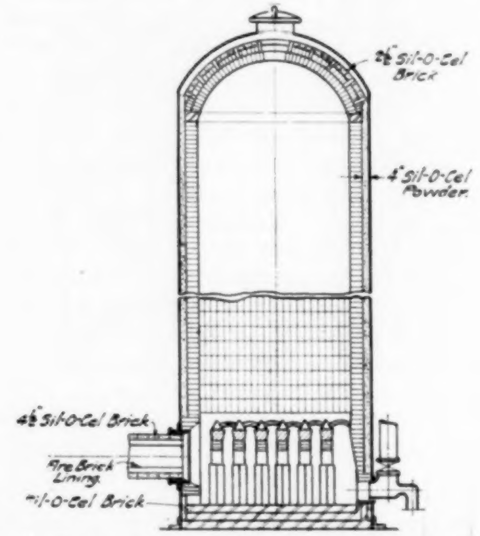


FIG. 6 SIL-O-CEL INSULATION OF HOT BLAST STOVE

an enumeration of them would seem a somewhat formidable array, there are products upon the market which fulfill practically all of them.

When the kind of refractory material that is best suited to the surface has been determined, the next most important item is the thickness of the walls and the nature of the insulating material most suitable, and it is necessary to determine the degree of insulation which will produce the most effective results.

In attempting to obtain perfect insulation, it is entirely possible to over-insulate, causing a serious damage to the refractories in the high temperature zones of the furnace. To maintain the inner walls, it may be necessary to permit a considerable flow of heat through the wall, with a corresponding decrease in the temperature of the refractories at the heated point, in order to prevent their destruction.

However, the issue in some instances may be met by other practical methods, such as increasing the working capacity of the unit in order to make use of the additional heat available, rather than to let this valuable heat at the critical period

escape to save the refractory lining,—a method which makes the working load control the temperature.

In electric-furnace practice, where extremely high temperatures are encountered and where effective insulation is necessary because of the relatively high cost of current, the question of insulation or rather over-insulation, has been given more attention than in other lines.

DESCRIPTION OF CELITE

The requirements of an ideal insulator being known, it remains only to select such an insulator as apparently most nearly meets these requirements.

A material possessing remarkable non-conducting properties is "Celite," so-called on account of its extremely cellular nature. It is a mineral of a highly siliceous composition and of very light weight, and occurs on the Pacific Coast in an exceptionally pure state. Fig. 8 shows the material being quarried. It is composed of numerous hollow cells, and weighs in its natural rock form, air-dried, from 25 to 30 lb. per cu. ft. When this material is ground properly, it weighs but 8 lb. to the cubic foot, and has a thermal insulating power of about 9 to 12 times the insulating power of ordinary firebrick. In other words, a 1-in. layer of this material is the equivalent in insulating value of from 9 to 12 in. of firebrick. Being almost pure silica, its melting point is high, 2930 deg. fahr. (1610 deg. cent.) as reported by the U. S. Bureau of Standards, and it can be subjected to high temperatures without fear of alteration.

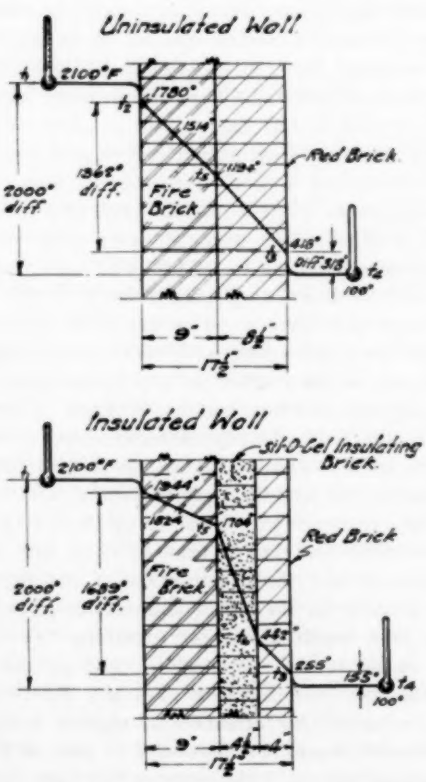


Fig. 7 Heat Flow and Temperature Gradient Through Heated Walls

Bricks and blocks of various sizes and shapes are prepared by sawing the natural material by means of gang saws. Standard 9-in. straight "Sil-o-cel" brick made from natural celite weigh from $1\frac{1}{2}$ to 2 lb. each, and are equivalent in insulating value to many times their thickness of ordinary firebrick. In crushing strength these bricks withstand over 400 lb. per sq. in. and are sufficiently strong to stand transportation and handling.

The cost of these insulating bricks is but little more than that of firebrick, and that of the powder about one-third as much.

Because of the variation in forms in which Sil-o-cel products are supplied—that of brick, blocks of various shapes, in powdered form and as a plastic cement—this material is adaptable to almost any form of thermal insulation, as will be shown in the following typical examples.

Fig. 8 Celite Being Quarried on Pacific Coast

GENERAL TYPES

Fig. 1 indicates the usual method of using Sil-o-cel brick interlaid between a course of firebrick and red brick for the prevention of heat leakage through walls.

Fig. 2 indicates one of the methods of construction of an insulating wall in which an otherwise hollow space is filled with insulating powder. From 2 to 4 in. is usually sufficient. The powder is packed slightly to a density of approximately 12 lb. to the cubic foot, at which point it attains its maximum insulating value and is not subject to settling or contraction due to either vibration or heat. Where this form of construction has been in severe service in high-temperature furnaces for a period of years, no contraction or settling has taken place. Fig. 9 illustrates the cohesion of the material.

Figs. 3 and 4 indicate the methods of insulating brick walls which are already in place. In Fig. 3, expanded metal lath is erected on an angle iron at the required distance from the outer wall and coated on the outside with one or more coats of Portland cement plaster, to which approximately 20 per cent by volume of Sil-o-cel powder has been added to give greater plasticity and ease of working and to increase the heat-resisting properties of the cement. Sil-o-cel powder is packed to a density of 12 to 15 lb. per cubic foot between the brick wall and the expanded metal lath. In Fig. 4 the powder is packed between the brick wall and a metal casing.

Fig. 5 illustrates the insulation of boiler settings by means of Sil-o-cel insulating brick (left hand diagram and tops of both diagrams) and by means of Sil-o-cel powder in a hollow wall (right hand diagram).

Hot-blast stoves, Fig. 6, provide an excellent example of the requirements of an insulation for high-temperature work, not so much because of the high temperature to which they are subjected, but more especially because of the size, expansion and contraction of lining and shell, settling, shrinkage, elasticity and corrosion of the insulator and protection of the shell itself, the constant change in temperature and other factors.

In a 20 x 100-ft. stove, for instance, the column of brick in the lining may expand through heat as much as 5 or 6 in. in height from cold to maximum heat. Therefore, the insulator may be considered at all times being subjected to a certain amount of stress and friction requiring an elastic medium which will take up these continued strains without injury or danger of being crushed, which would result, as in the case of granular slag, in constant settling, the accumulation of fine material causing occasional bulging of the shell at the base of the stove on account of its inelastic nature. Two principal

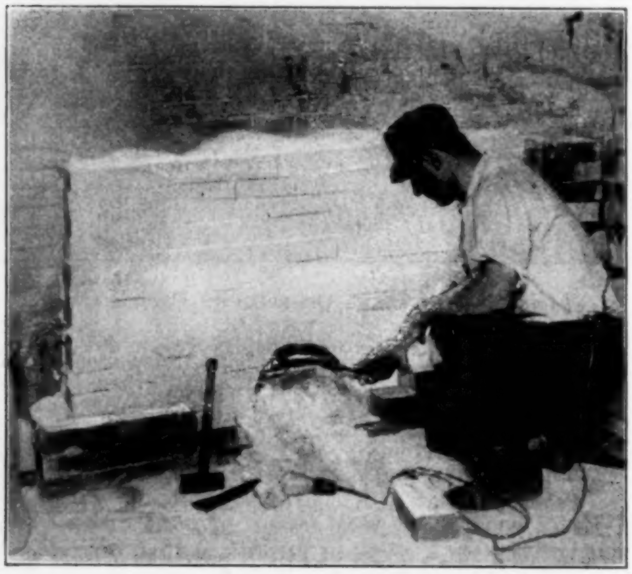


FIG. 9 COHESION OF SIL-O-CEL POWDER AFTER REMOVAL OF FRONT AND END SUPPORTING WALLS

requirements of the insulator for this purpose are, then, elasticity with still sufficient strength to give the proper support to the brickwork and shell, and the proper amount of cohesion or high internal coefficient of friction and light weight so as to overcome any tendency toward settling under the movement or vibration of the stove.

Recent tests of a battery of stoves and mains insulated with Sil-o-cel powder and brick, as indicated in the illustration, prove conclusively not only that can a higher capacity be obtained from the blast furnace by insulating to produce a more uniform temperature throughout the stoves, but that a more uniform grade of product can be made by eliminating fluctuations in the temperature of the blast itself.

A report of a test carried out in a blast furnace, the bustle pipe of which was insulated with Sil-o-cel insulating brick, shows that the actual temperature of the blast at the tuyeres on the side of the blast furnace farthest from the main is more nearly the main temperature than can be obtained without insulation, in fact there is practically no temperature drop of the gases during their passage through the bustle pipe. This is due to preventing the radiation losses from the outside of the bustle pipe and gives a more uniform heat distribution through the stack and better temperature control.

Water containing ten grains per gallon of incrusting material used in a 500 h.p. boiler operating at normal rating and generating 15,000 lb. of steam per hour, has been stated to deposit about 3 lb. of scale per hr. The same boiler when operating at 100 per cent overload and generating 30,000 lb. of steam per hour, deposited 6 lb. of scale per hour. Not only was twice as much scale thus deposited, but the scale was baked harder to the tubes and boiler surfaces.

Many tests have been made upon engines using saturated and superheated steam under varying conditions, and all show a saving in steam consumption per unit of power developed when using a superheater. The ultimate gain, when the cost of equipment, depreciation, operation, etc., are taken into account, will vary, and while it is usually a substantial one, there may be cases where the use of superheated steam will result in a loss. Prof. G. F. Gebhardt, Mem.Am.Soc.M.E., gives the average reductions in steam consumption with superheating from 100 to 125 deg., based on continuous operation in existing plants, as from 40 per cent with slow-running, full stroke, or throttling engines, including direct-acting pumps, to 6 per cent with triple-expansion engines. Although large savings in fuel have been made in some cases by the use of a superheater, amounting to its first cost each year, these are not common; however, they should be favorably considered if their use would effect a net saving of 10 per cent on the first cost above depreciation and maintenance charges; a result which should be reached in any plant operated at one-third its capacity and burning coal at $2.00 or over per ton.

Owing to the lesser density of superheated steam, as compared with saturated steam, it is possible to employ much higher velocities of flow through the piping, and this in many cases permits reduction of pipe areas of 20 to 50 per cent. It must, however, be carefully borne in mind that certain materials entering into the construction of the piping system should be suitable for the higher temperature steam, and while there has been much discussion regarding the comparative merits of cast-iron and cast-steel for fittings and valves for this purpose, there does not seem to be any general agreement.

In comparing the performances of engines using saturated and superheated steam, it is necessary to base all results upon the *heat* consumed per horsepower rather than on the *steam* consumption in order to get a true comparison. While a saving in the weight of steam per unit of power developed by the engine may be obtained, it does not follow that the saving in fuel is in the same proportion, because the total heat contained in a pound of superheated steam at a given pressure is greater than that in saturated steam at the same pressure.

Another important item to be taken into account, especially in case of a new plant, is the reduction in boiler equipment. In the case of a plant already in operation, the addition of superheaters will give one or more reserve boilers.

All superheaters should be provided with safety valves set to blow at a pressure slightly below that of the boiler valves. This is necessary in order to insure a flow of steam through the superheater in case the load is suddenly thrown off the boiler; or overheating would be likely to take place.

In this country steam temperatures seldom exceed 500 deg., while in Europe 600 deg. is a common temperature, with a maximum of 850 deg.—Charles L. Hubbard, in *The Engineering Magazine,* June 1916.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

RELATION OF ENGINEERING SOCIETIES TO LEGISLATION AND PUBLIC AFFAIRS

To the Editor:

There was recently before the Engineers' Club of Philadelphia a question of the advisability of the Club going on record in favor of or against legislation in general.

A conviction has been growing for some time in the engineering world that engineers should and must take a place in the community in the shaping of public affairs—a place more in accord with the importance of engineering in the economic and social political affairs and life of the commonwealth.

Any citizen who feels that he can be of benefit to his fellows by placing his abilities at their disposal in aiding or carrying out legislation ought to consider it his duty to do so. That duty of the citizen is also a duty of the engineer as a citizen. In so far as the engineer has become, by training and experience, more thoroughly fitted for and more intimately acquainted with the community's needs, just so far is that duty of citizenship more definitely placed upon his shoulders.

Whatever holds for the individual engineer is true also for the engineer as a member of an engineering society, and again for engineers collectively through such societies.

A recognition of such duty is expressed in the charters, constitutions and by-laws of most engineering associations, in nearly all of which the furtherance of the public welfare, in so far as that may be affected by engineering activities, is stated as a fundamental purpose. With that recognition there is opened up the question of how best to realize this purpose.

The individual engineer will act in accord with the dictates of his personal conception of his duties as an individual citizen; that may lead him to offer himself as a candidate for and to accept public office as an executive or legislator, or to offer advice and counsel and advocate certain definite legislation. Can engineers collectively, when banded together into societies, follow, in carrying out their duties of citizenship, the same line of activity as the individual engineer?

Manifestly not altogether. Public office and direct legislation are restricted to the individual and are, at the present stage of the world's affairs, not open to societies. But the proffer of counsel and advice and the advocacy of legislation are activities as open to societies as to individuals.

It is true, moreover, that along these lines collective action by associations is apt to be more forcible and fruitful than similar action by a similar number of individuals acting separately. As this may be accepted as so self-evident as to be axiomatic, there remains for consideration the relative advisability of counsel as a basis for legislation as opposed to direct advocacy of special legislation.

As between these alternatives the choice ought to be governed solely by consideration of their relative effectiveness. It is granted that the only aim in the pursuance of either course is the incorporation into the conduct of communal affairs of such rules, regulations and laws as engineers collectively may have found through special training and experience to be best.

Man is known to be selfish and the more so as he lives for himself alone. This individual selfishness comes less to the fore as men band themselves into communities, partly by reason of the fundamental evolution to higher and higher ethics of conduct, and more immediately because the effect of community action is less directly connected with and traceable to the individual's personal interest.

When a person advocates a certain course, others are prone to ask "what has he to gain—what axe has he to grind?" Though the answer may be, and in all sincerity will be, "none," men are suspicious and not apt to accept such answer at its face value. This very natural attitude of doubt and tendency to impugn motives will be lessened the more, the more remote the advocate's personal interest is recognized to be.

When any of us wish to adopt the best possible course for any familiar undertaking or endeavor, what do we do? We secure the best advice procurable and from counselors who are best fitted by training, experience and expert knowledge in the particular field or specially involved. We go to the doctor, the lawyer, the engineer, as the case may be. More and more are communities following the same practice. Unfortunately, it is no new experience that individuals of great skill are found to have a personal interest that interferes with their ability to give entirely unbiased advice.

How safeguard against that? Why not, by securing the advice, not of an individual, but of a professional group widely representative of the aggregate training and experience of the community's specialists?

While individual elements of a group may have selfish motives, the very diversity of interests will rarely allow that of any one unit to govern, with the result that the collective sense of the majority will usually be fairly sound and but little tainted by self-interest.

If we felt ill would we consult a lawyer or an engineer? The answer is superfluous. Just as in such case we would see a medical man, we would in other circumstances seek legal or engineering aid.

Would we be likely to heed unsought advice, whether medical, legal or engineering, or would we give both ear and weight to that coming in response to our direct request and asked of those in whom we had faith? Again, the answer is self-evident.

To sum up, the best advice is always that of the trained specialist; the most disinterested counsel is that based on the collective experience of grouped specialists.

This brings us fairly to the question of the advisability of the Engineers' Club of Philadelphia going on record in favor of or against legislation in general.

Actually the question should be stated more broadly:

"How best can Engineering Associations, including our Club of Philadelphia Engineers, place their collective engineering knowledge, experience and training at the service of the community?"

Two ways are debatable: A stand in favor of or against direct legislation may be taken, or engineering matters affecting the community may be carefully considered and formu-

lated, to serve as a guide and basis for the formulation into laws by those more specifically fitted by experience and training in the framing of laws.

Some, at least, of the great national engineering societies, some by practice and some by direct constitutional requirement, have decided to absolutely refrain from recommending or formulating laws and to limit themselves to specific engineering advice and recommendation. In so restricting themselves, they have actually broadened and deepened their influence on actual legislation. They have not sought, nor do they seek, to influence legislation, and in so refraining they have actually gained a deep and beneficial influence in and for the community.

As any course of reasoning is most forcible when backed up by actual results, a case in point might here be cited. It is that of the A. S. M. E. Boiler Code Committee.

A number of engineers, members of the Society, largely interested in steam boilers and their safe construction and use, got together a number of years ago and were constituted into a special committee. Some members were fundamentally interested in safety alone, with no financial interests in any particular form or type of boiler; others were directly interested in some type or accessory detail. It was soon recognized that the matter was so broad and that it so fundamentally affected the entire community, not simply builders of boilers, that the committee was expanded until it actually represented the best specialized engineering talent of the entire country and covered every phase involved. The natural tendency of many individuals to look after only their own particular interests brought out their best arguments, to be countered by those of others possessed of conflicting interests, with the final result that a Code for boiler construction was evolved that, while restraining no maker of any particular type of boiler, made certain that any boiler built and used under the Code was as safe as the combined experience and skill of the designing, manufacturing and operating engineers of the country could evolve.

Did the engineering associations that participated in this work recommend the adoption of the Code as the law of the land? Many members of the committee most earnestly demanded that that should be done, but wiser counsel prevailed. The Code was published simply as what it was—the crystallization of the best knowledge of the engineering profession.

And what was the legislative result? Various legislatures in various States secured copies; some had the Code reprinted *in toto*, and many used it as the basis for a revision of their boiler laws. A number of legislatures have incorporated the Code in whole or in part into organic law.

Nowhere was the Code objected to, as must inevitably have been the case had its framers worked for the adoption into law. No point was raised of a selfish motive or a selfish end to be gained for any maker of a boiler or of a boiler accessory.

Even those engineers who advocated their societies putting themselves behind the enactment of the Code into law are now agreed that what they hoped for in the interest of the public and community actually came about much sooner and more readily as a result of their confining themselves to their special domain.

The above argument was presented before the Engineers' Club of Philadelphia by the writer, who, in order to bring out a discussion directed to a definite issue, followed it by this motion:

Whereas, it is the sense of the Engineers' Club of Philadelphia that Engineering Associations can best fulfill one of the basic purposes of their existence—that of serving the community, by bringing to bear on any particular phase of engineering involving the public welfare, the collective knowledge, training and experience of engineers and of the profession of engineering:

Therefore be it resolved that:

"The Engineers' Club of Philadelphia shall recommend neither legislation nor laws, but shall restrict itself to the formulation of the collective knowledge and experience of its members on any particular phase fundamentally involving engineering practice in the erecting or manufacture of engineering structures or constructions, which formulation may serve to guide those seeking the best collective knowledge of those fitted by engineering training and experience."

The writer's views upon this subject are here submitted for The Journal in the hope that they may stimulate thought and draw forth representative opinions which will be of guidance to the Society and to other organizations in any future questions concerning the engineering societies and legislation and public affairs.

Henry Hess.

Philadelphia, Pa.

MANUFACTURERS AND THE INDUSTRIAL INVENTORY

To the Editor:

As indicative of the frame of mind in which many of the manufacturers of this country find themselves, the replies which the writer and other members of the local committee on the Naval Consulting Board have received in response to their communications in regard to the Industrial Inventory are very illuminating. We arranged to send out return notice postcards with all the inventories, and delivered them by a messenger so as to avoid any trouble with the post office and any excuse that the mail was not received. Less than 10 per cent of the return postcards were mailed to us. After about ten days, the firms were approached by telephone and about 50 per cent replied that they did not see why they should fill out the inventory because they did not make any war material, and did not see what connection they had with it. Of course, the reply to this objection is, that practically every business is affected in case of a large war. It even applies to such apparently far removed businesses as hosiery, underwear and other clothing manufacturers. Most of the firms seemed to think that the only materials required in a war are rifles and ammunition. They forget altogether that the biggest part of supplies to an army are other materials than those for killing.

Not less than two men raised the objection that they did not believe that we ever would have a war, that they were staunch Wilson men, and as President Wilson had kept us out of war so far, he would probably continue to do it. The reply seems almost obvious, considering the conditions in Mexico. I have also asked these objectors what they think is going to be the position of the U. S. after the war, when the comparatively impoverished European countries with heavy holdings in Mexico are going to call this country to account for either bringing conditions to a proper state in Mexico or abandoning the Monroe Doctrine.

One manufacturer characterized the effort to get the inventory as "all nonsense," although I could tell from his replies that he had not even read the papers. Another objection is raised by the excuse that they are too busy and have not found time to fill out the inventory, some claiming that it takes them

about a week to do it. To this the reply is that it need not take more than two or three hours, if they go at it earnestly; and also that the information they obtain will be of benefit to themselves as well as to us. It seems hard to get them to realize that this matter is of much benefit, or more, to the manufacturers themselves than it is to the Government.

In all it would appear as if the average manufacturer did not take the situation in this country seriously enough, and I think that the publication of this information in The Journal, where it would be likely to reach a good many intelligent engineers by a more authoritative channel than usual, will have some influence upon the attitude of the manufacturers with whom they are employed.

It seems to me that as intelligent and energetic a campaign as the present one conducted by the five engineering societies, should receive all the support possible with a view to increasing the efficiency generally of governmental engineering matters.

R. J. S. Pigott.

Bridgeport, Conn.

About 90 per cent of the manufacturers in the countries involved in the European war are engaged in the production of materials which may be broadly classed as munitions. The guns, powder and shells represent but one phase of this work. There are nearly 35,000 items in the purchasing lists of the departments responsible for the maintenance of an army under effective fighting conditions. More than 4000 of the larger manufacturing plants in England alone have been taken over by the government, and are now being operated under government control. In addition to this unprecedented industrial activity in all the countries of Europe and in Japan, a large percentage of the manufacturing establishments of neutral countries, including the United States, have been called into munitions service for the supply of materials to the Allies.

In the event of any war in which this country becomes involved, every manufacturing plant within the boundaries of the country will be called upon to do its part for the national service. It goes without saying that no manufacturing institution in this country can, without months of fatal delay, begin to produce army and navy materials unless it has in time of peace been carefully taught the intricate methods and processes involved in the making of such emergency product.

True preparedness in this country can exist only through such an organization as will, in the event of emergency, place our manufacturing and producing resources instantly at the government service, and any and every plan for the protection of this country against invasion may be made effective only through such organization. Every manufacturer must take this great lesson of the European war home to himself, and realize his responsibilities under it. Every manufacturer must demand that he be taught, in time of peace, to make that thing for the Government for which his equipment and the training of his men best fit him, and which he will be required to supply for the support of the Army and the Navy or the civilian population in time of war.

In thus demanding that, through prearrangement, his manufacturing facilities be made readily and quickly available to the Government in time of need, the manufacturer at this same time serves his own best interest. He insures the operation of his plant at a reasonable profit in spite of the chaotic commercial conditions attendant upon war, and that his labor organization built up over a long period of years will be maintained intact as an integral part of the Industrial Reserve.—Editor.

STUMPF UNAFLOW ENGINE

To the Editor:

In the July issue of The Journal Mr. Wm. E. Bullock objected to the credit given to Prof. Johann Stumpf, of Charlottenburg, for the development of the Unaflow Engine.

It is evident, from the examples which Mr. Bullock gives, that the principle which Professor Stumpf invented, and which made such a remarkable success of his engine, is not understood. If Mr. Bullock would build the engine shown by Todd, or the engine illustrated in the patent to John M. Hirlinger, he would find that the economy recently secured by the Stumpf unaflow engine would not be obtained.

Professor Stumpf, as he stated in his book, was not aware of the patent to Todd, but devised the arrangement of cylinder, piston, inlet ports and exhaust ports from theoretical considerations, and used this construction only as a means for carrying out his real invention.

Professor Stumpf added to the Todd, Hirlinger, and several other unsuccessful engines—in which the steam entered the head end of the cylinder and was discharged at the middle—a steam jacket, through which was circulated the hottest steam. This steam jacket was located at the inlet ends and was protected by all available means from the colder cylinder spaces.

The cylinder surfaces near the inlet end were thereby maintained hot and dry during both expansion and compression strokes. The water of condensation, therefore, became concentrated on the colder cylinder surfaces near exhaust which never came in contact with the high temperature steam. When exhaust opens the wettest steam is eliminated and the dryer steam remaining is trapped by the returning piston and compressed against the heated inlet surfaces, receiving heat both from the jacket and the work of compression and producing a temperature in the clearance steam and the cylinder surfaces higher than that of the steam entering from the boiler. This prevents initial condensation on these surfaces to a degree which no other builder of unaflow engines approached, even remotely.

In designing his engine Professor Stumpf also reduced the area of the entrance port to the minimum. When local conditions required more heat he also jacketed a portion of the cylinder as well as the head, at the same time reducing the section of metal between that jacket and the exhaust port to the minimum.

The long piston kept the cylinder covered from contact with the exhaust steam for the longest possible time, thus preventing the extraction of heat from the cylinder wall, and its conveyance away by the exhaust.

It is evident that both Todd and Hirlinger invented a mechanism rather than a principle of operation. They both provided long entrance ports, with a surface that would be subject to changes of temperature, and which were not jacketed, and located their steam chests over the center of the cylinder where the heat could be readily conducted to the exhaust, and they did not heat the cylinder head.

An actual experiment has been made with a Corliss engine cylinder, first with Corliss exhaust valves at the head, and then with ports in the center of the cylinder. The results of careful tests showed very little gain in economy by the use of the central ports as compared with the ordinary exhaust valve, these experiments being made without any head jacket. When, however, the head jacket was introduced the economy of the engine was increased to correspond with the figures obtained by Professor Stumpf.

The tremendous success which Stumpf's unaflow engines have had in Germany, where some 600,000 or 700,000 h.p. had been built before the war, is a practical demonstration of the efficiency of his system, and he is therefore entitled to the credit for the success of the unaflow engine.

Some two years ago the writer saw in actual operation over 40,000 h.p. of these engines, built by Sulzer Brothers, and Ehrhardt and Sehmer, from 100 to 8000 h.p. in a single cylinder. These engines were running under all sorts of conditions, direct driven with generators attached, and in the case of the 8000 h.p. engine, direct connected to a 3-high train rolling mill. They were beautiful engines, extraordinarily well built, and operated perfectly.

The official government tests showed a steam consumption with ordinary vacuums of 9.5 lb. of steam of 150 lb. gauge pressure per i.h.p-hr. for engines of 500 h.p., which was better consumption than 1600 h.p. triple expansion engines made by the same companies, running alongside of them and tested under the same conditions. These results had become so well known in Germany that it was very difficult to sell anything but Stumpf unaflow engines, and the only competition was between makers of this type.

The United States is very much behind in the adoption of this type of machine, and while there are several American inventors who attempted the solution of this problem, they always failed to make the proper combination, and it was not until Professor Stumpf perfected his unaflow cycle that the economies, which warranted the construction of these machines, were obtained.

There are several examples in the prior art, from 1850 to 1885, of patents for unaflow engines, all of which missed realizing the vital principles of the engine which Stumpf finally developed in 1908. These only increase the credit which should be due him, as in spite of all this information, which was accessible to the thousands of engineers who were struggling to improve the economy of the steam engine, the use of multiple cylinders, with their many losses and complications, appeared to them to be the only solution.

EDWARD N. TRUMP.

Syracuse, N. Y.

THE GREAT NEED OF OUR INDUSTRIES AND CITIZENSHIP

TO THE EDITOR:

So much has been said recently upon the subjects of economic, social and civic preparedness, and our opportunities for making our country rank foremost with the other nations of the world have been pointed out in the columns of The Journal and elsewhere. The fact remains, however, that our factories are still looking for men, and men are looking for work.

What will become of our national industrial advancement unless engineers are soon provided with a body of thought on the part of workmen who must be depended upon for the execution of their plans? Where is the trouble?

Corporations have found it necessary to establish their own private schools. It was vital for them to have a certain number of skilled mechanics "coming along" to take care of the growth of business and replace those who are eliminated. It cost one corporation one thousand dollars a month just for waste material due to the inefficiency of a part of their so-called skilled workmen. A prominent decorator who had a large contract to finish hired six men in one day and the same night had to discharge five of them.

In one factory a large number of men were waiting at the employment office. "What can you do?" was asked. The reply was, "Nothing." Here was the factory tied up with work in search of employees and could not get them, and here were the men looking for employment but could not find it.

That, of course, is greatly intensified in large cities and large plants, but when you trace it down the condition is commensurate with and proportional to the size of the city and plant with equal importance.

The public school system has been regarded as one of our greatest and most democratic American institutions. Everyone thinks of it as wonderful and supreme in its management, direction and organization. One readily finds on analysis, however, that the system entails a tremendous loss, because it fails to fit the great mass of the people. On the other hand, it succeeds admirably in accomplishing the purpose it began—which is that of bringing the children from the first grade and the home up through the grammar school, the high school, into the college.

But there are 65 to 90 persons out of a hundred who are eliminated annually and thrown out upon the streets of every community with but little more than an average of six to seven years' schooling. Thus is industry supplied by the "slag" from the schools. These young people go out to recruit our skilled and efficient helpers and producers, to become future American citizens, and they have almost no training whatever.

In New York City it was recently shown that there were 86,000 children who entered the second grade of the grammar school. 42,000 of these graduated from the eighth grade. 23,000 entered the high school and but few over 4000 graduated.

What has become of the other eighty-odd thousand?

With the decline, due to specialization in industry and piecework, of apprenticeship as it existed in bringing forth the mechanics of today, it is impossible for the boy to receive his due quota of industrial training. As a result our industries and our people must suffer.

The ideal of the school system has changed, however, and it is beginning to bring education in touch with the industrial service of every community, large funds being appropriated annually by States and cities, while at the present time an appropriation of several millions is pending in Congress which will be dispersed as Federal aid. We have had to learn our lesson from the European countries and now it is pervading every State in the Union as an economic necessity.

The State of Wisconsin has adopted a unique and unusual plan, having taken advantage of the accumulated experience of Germany. Other States have adopted various other methods, differing according to their special condition.

We are facing the great problem of the unemployed, which is the result of our educational system, as a whole, not being entirely adapted to the welfare and vocational interests of all our people—except in so far as general schooling is generally helpful. We have been intensifying on the *self-respecting, intelligent* citizen. Let us see what can be done toward making him *self-supporting* as well.

In this lies our great opportunity for economic, social and civic preparedness which will make our country rank foremost with the other nations of the world.

FRANK L. GLYNN.

Madison, Wis.

Society Affairs

Engineering Survey

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES[1]

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEE

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee to Determine Cost of Electric Power
Conservation
Electrical Engineering Standards
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System
Nominating Committee, Walter B. Snow
Patent Laws
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

DETROIT and New Orleans have in the past month been added to the industrial centers where meetings of the Society will be regularly held. Close coöperation will be had between the new Sections and the local engineering societies of the respective cities, namely, the Detroit Engineering Society and the Louisiana Engineering Society. Similar coöperation with other national society sections is always the program of the Am.Soc.M.E. wherever it undertakes any work. The uniform policy is to build up a spirit of professional engineering and fraternity in each center with the local engineering society as the nucleus, the sections of the national societies coöperating.

The temporary committee in charge of the organization of the Detroit Section consists of R. Collamore, *Chairman;* F. H. Mason, *Secretary;* E. J. Burdick, H. H. Esselstyn (*ex officio*), W. R. Kales, and H. McCabe.

The Executive Committee of the New Orleans Section has been duly nominated by the local members and appointed by the Council and consists of W. B. Gregory, *Chairman*, Member of Council designate; H. L. Hutson, *Secretary-Treasurer;* R. J. Burwell, H. F. Rugan and E. W. Kerr.

Other centers which have plans for the establishment of Sections under way are Baltimore, Erie and Providence, and it is expected these will be fully developed in the fall.

Volume 37 of Transactions will be issued during the month to standing members in 1915. The page size, 6 in. x 9 in., is uniform with the preceding annual volumes. A synopsis of the contents is given below. The volume contains 1560 + XVIII pages, and is the largest annual volume ever issued by the Society. The work of preparation has been ably supervised by the Publication Committee, I. E. Moultrop, *Chairman.*

With the coöperation of the committees on Gas Power, Railroads, Machine Shop Practice, Industrial Buildings, Textiles, etc., the plans of the Committee on Meetings for the thirty-seventh Annual Meeting are developing rapidly. The Committee on Meetings calls attention to the necessity for receiving manuscripts of papers by September 20.

The Committee on Air Machinery reports that it has a large amount of research work on the measurement of air on hand in conjunction with the Navy Experiment Station at Annapolis.

The Research Committee, under the chairmanship of R. J. S. Pigott, has adopted a new plan of working this year. The Committee intends to hold three principal meetings, one on September 15, one on December 4, and the third before the Spring Meeting. At these meetings all the members of the Committee are expected to be present, as well as the chairmen and members of the sub-committees. The chairmen of all sub-committees report each month in writing to the chairman of the Standing Committee the progress made by the sub-committee during the month.

WELCOME THE AMERICAN SOCIETY OF CIVIL ENGINEERS!

Civil Engineers to Share Engineering Societies Building

The American Society of Civil Engineers has voted to accept the offer of the United Engineering Society to become an equal partner with the three Founder Societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and The American Society of Mechanical Engineers in ownership, occupancy and administration of the Engineering Societies Building and all other activities which the Societies may jointly undertake. Thus is the hope of Mr. Andrew Carnegie, the donor of the building, fully realized—that the building should become the home and headquarters of the engineering profession in America.

The action of the Civil Engineers is the result of a letter ballot of its entire membership. This ballot closed on June 15 and was announced at the Pittsburgh convention of the society on June 27. The vote was six to one in favor of the removal of the society from its present headquarters on 57th St., New York.

Three stories will be added to the top of the Engineering Societies Building and specially planned for the extension of the Library and for the use of the Civil Engineers. The cost will not exceed $250,000. The arrangement with the Civil Engineers is to permit them to reimburse the United Engineering Society for the cost of the enlarged building, this sum being substantially the same as the amount paid by the Founder Societies originally for their participation in the enterprise. Thus all four societies enter upon the same basis and share equally in all respects.

Ten years ago, at the time the Engineering Societies Building was constructed, the Civil Engineers were invited by Mr. Carnegie to be a Founder Society in the Building. They decided at that time not to accept the offer, however, but to continue to occupy their own house on 57th Street, which they had built about ten years earlier.

At the time of the undertaking of the Founder Societies, there was doubt as to the success, financially and technically, of the scheme for associating several societies in one building. The construction and dedication of the building were looked upon by some as the first steps of a severe trial of the management of the societies. Many questioned whether the three participating societies in Mr. Carnegie's gift would live together in harmony and be able to carry out the plans suggested. Some questioned the feasibility also of uniting the three independent libraries of the societies into one joint library, useful to members of any of the three societies for research and consultation. Some did not see how the housing of the three national societies and several minor associations under one roof would bring about the desirable closer coöperation of the various members of the profession, without at the same time causing some of the organizations to be "swallowed up" by some of the others.

The experience of ten years has shown that all these criticisms of the project have become groundless. The financial stability of the Engineering Societies Building is now fully established. The building represents an investment of practically \$2,000,000. The societies own it free of all encumbrance, and have in addition over \$70,000 in a separate reserve fund to provide for depreciation and amortization. Each society has itself prospered. The Civil Engineers will now pay about \$225,000 for the addition to the building, and each of the four Founder Societies will then hold an equity in the property of over half a million dollars.

Eighteen societies, including the three original Founder Societies, now make the building their headquarters. Each is under its own management absolutely, and all live in independence and harmony. Frequent conferences are held in matters pertaining to the welfare of the engineering profession as a whole.

With the Civil Engineers, the total membership represented in the building will be 52,677, as shown by the following figures of present membership of the resident societies:

American Society of Civil Engineers	8022
American Institute of Electrical Engineers	8308
American Institute of Mining Engineers	5597
The American Society of Mechanical Engineers	7149
Aeronautical Society of America	200
American Society of Heating and Ventilating Engineers	705
American Gas Institute	1530
Association of Edison Illuminating Companies	73
American Institute of Aeronautical Engineers	121
Empire Gas and Electric Association	115
Illuminating Engineering Society	1350
Municipal Engineers of the City of New York	600
National Electric Light Association	14000
National Association of Engine and Boat Manufacturers	175
New York Electrical Society	705
Society for Electrical Development	1128
Society of Naval Architects and Marine Engineers	900
Society of Automobile Engineers	1975
U. S. Naval Consulting Board	24

Truly the aspirations of Mr. Charles F. Scott, Past President of the American Institute of Electrical Engineers, Mem. Am.Soc.M.E., who in 1902 pictured a magnificent building, the "Capitol of American Engineering," and the hopes of those progressive engineers who have so long worked in various ways toward the common end, will now be fully realized, when this enormous membership—the largest in the world under one roof—is concentrated in one headquarters.

The Joint Library of the United Engineering Society has in ten years become the greatest and potentially the most useful engineering library in the world. Accessions are now being made at the rate of three thousand annually, and the collection amounted, at the time of the last annual report of the Library Board, to over 62,500 volumes. 1020 publications were at that date being received periodically, and current numbers of over 1000 periodicals were on file upon the shelves in the reading room so as to be readily accessible. The consolidation of the valuable Civil Engineers Library with the others will enlarge the scope of the Library so that it will become of use to any member of the entire engineering profession.

There has been of late an increasing amount of coöperation between the societies through their governing bodies in matters affecting the general welfare of the engineering profession. There has likewise been increasing and notable coöperation between the Government and the societies. There has been increasing coöperation between the parent societies and their local affiliations, and in turn there has been increasing coöperation with the local affiliations of the various societies with each other.

The testimony of all will therefore be that the action of the Civil Engineers to come in establishes their desire to do their part in the great coöperative movement in which the engineers of America are engaged for the purpose of promoting the welfare of the profession as a whole and, through it, of the public at large.

VOLUME 37 OF TRANSACTIONS

The affairs of the Society during the year 1915 are recorded in Volume 37 of Transactions, to be issued during the month of August to standing members in 1915. A general review of the work of the Society for this year is given in the Annual Report of the Council included. The Volume contains a calendar of all the meetings of the Society—general meetings and local meetings—held during the year; and the papers, with discussion, presented at the Spring Meeting in Buffalo, April, 1915, the Annual Meeting in New York, December, 1915, and the additional general meeting in San Francisco, September, 1915, in connection with the Panama-Pacific International Exposition and the International Engineering Congress, 1915, are published practically in full. Papers read at local meetings and presented subsequently at a general meeting are also included; other local meeting papers will be found in The Journal, where a more detailed account of the local meetings is given. The reports of special committees received by the Council during 1915 and ordered published are included in the volume; of special note among these is the report of the Power Test Committee. The reports of Standing Committees for the year are published in The Journal, December, 1915.

A member's badge was recently found in Chambers Street, New York City, near the Sixth Avenue Elevated Railway. The badge will be returned to its owner upon application to the Secretary.

The United Engineering Society has installed a photographic duplicating machine for the reproduction of pages from books and periodicals, maps and charts, in the Library of the Engineering Societies, and it is now in operation. Orders may be sent to the Library of the Engineering Societies, 29 West 39th St., New York.

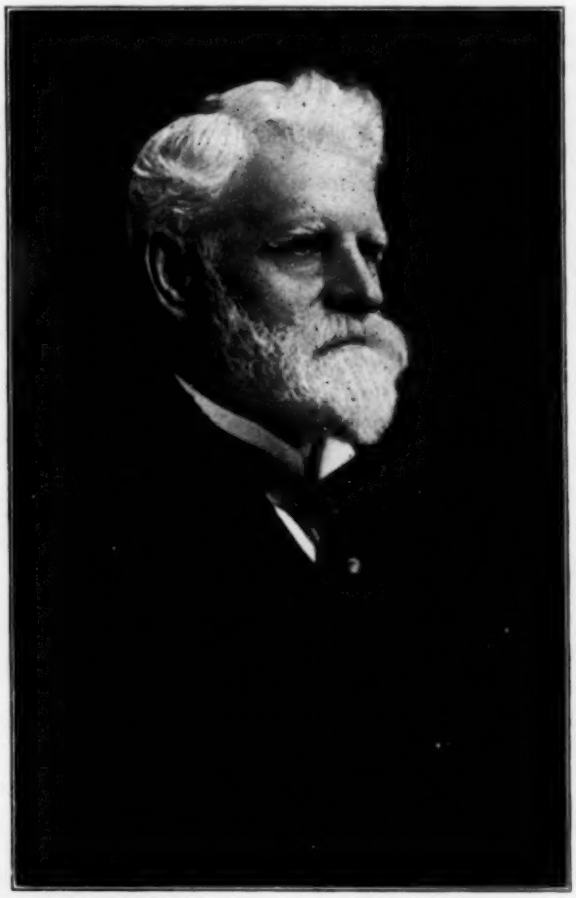
The process produces a photograph (white on black) direct on bromide paper, and from this negative print a positive may be made by re-photographing. The charge for a print 11 in. x 14 in., which may cover two pages of an octavo volume which face each other, is 25 cents for a negative print and 50 cents for a positive print. Enlargements and reductions up to 11 in. x 14 in. are easily made. The process has the advantage of accuracy and cheapness.

A Minnesota Joint Engineering Board has recently been proposed for the purpose of securing the most effective coöperation among engineers of various affiliations for the welfare of the profession, to correlate the work of the various engineering associations in that State for unity of action, and to work generally for the betterment of the standards of practice and clearer recognition of the engineer as a civic asset.

AMBROSE SWASEY ELECTED HONORARY MEMBER

PERHAPS no more fitting name was ever added to the list of illustrious men who have been honored by the Society than that of Ambrose Swasey, student, scientist, inventor, mechanical engineer, traveler, philanthropist and man of affairs, who has just been elected to honorary membership in the Society.

Certainly no engineer living merits more the distinction of being ranked by the Society with Holley, Eiffel, Sweet, Edison, Brashear, Leavitt, Bessemer, Westinghouse, Isherwood, and a score or more of others whose names grace its list of honorary members, than does Dr. Swasey. If he were only known (with his partner) for his achievements in constructing and erecting the largest telescopes ever made his fame would be assured, but, coupled with this attainment, his genius as an inventor, his ever increasing efforts toward advancement of the engineering profession and education in general, his unselfish generosity, and his wholehearted interest in other people, have more than obligated for him any recognition it is in the power of any individuals or associations of individuals to bestow.



Ambrose Swasey

The story of Mr. Swasey's life is a continuous record of tasks planned, carried through with perfect method, and completed precisely as planned. To attempt to enumerate these in the short space of an article would be futile, and a description of any one of them would reveal his remarkable character, his aptitude for detail and the precision to which he works. For instance, in each of his journeys around the world—and he has made two such complete journeys—he always prepared and printed in advance a complete itinerary covering the whole trip from the day of leaving Cleveland to the day of returning, and this he carried out to the letter, returning precisely on the day indicated. The preparation and carrying out of such an itinerary was but an infinitesimal task compared with the planning and execution of the epoch-making professional works in which he has engaged, but it well illustrates his capacity for taking pains, which is the essence of all genius.

Sketches of Mr. Swasey's life have been written a number of times, but the facts and incidents are so interesting and instructive as to be well worth reviewing again.

Ambrose Swasey was born in Exeter, N. H., in 1846, and like many of the foremost engineers in the country he never had the advantages of what is known as a technical education, but received what schooling he had in the Little Red Schoolhouse. At the age of eighteen he entered upon the machinist's trade in Exeter, and while learning his trade, Worcester R. Warner came to the same shop and began his apprenticeship, and the two struck up a companionship. In 1870, in company with Mr. Warner, he left his native state to enter the employ of the Pratt and Whitney Company at Hartford, Conn. His energy and ability soon attracted attention, and his aptness in the solution of mechanical problems was soon called into demand. While in charge of the gearing department, he invented and perfected the epicycloidal milling machine, and a few years later an entirely new process for generating and cutting spur gears which proved a practical solution of the very important factor of the interchangeable system of gearing.

In 1880 began that remarkable business association—the firm of Warner and Swasey, with the history of which all mechanical engineers in America are familiar. Its original business was that of machine construction, but Mr. Warner's taste for astronomy and his interest in the appliances used by astronomers, combined with Mr. Swasey's love of design and his ability as a mechanical engineer, naturally led them into the perfection and manufacture of astronomical instruments. The history of the firm's work in this field is linked with the history of the development of large telescopes from the time of the 36-in. refractor constructed by that firm for the Lick Observatory in 1886 (at that time the largest and most powerful ever constructed and a radical departure in design from any previous standards) to the present, which includes the completion and installation of the present largest telescope, the 72-in. reflecting telescope for the Dominion Astronomical Observatory, Victoria, Canada, described in The Journal, July, 1916.

The manufacture of meridian circles, transits and other astronomical instruments of extreme accuracy and precision has formed a large part of the firm's work, and in the designing of all these instruments Dr. Swasey has taken a prominent part. He took up the problem of designing a dividing engine of sufficient accuracy for graduating astronomical circles, and perfected such an engine capable of automatically dividing circles up to 40 in. in diameter, within an error of less than one second of arc. He has also given special attention to the development of instruments of precision for use in sea-coast defense, and the notable Swasey depression range finder, adopted by the United States Government, is by far the most perfect and most practical ever invented.

Turning from his engineering achievements, one's mind is

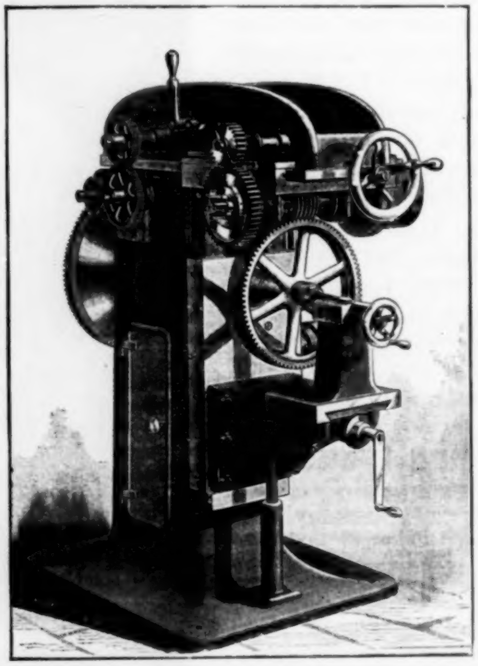
focused upon his philanthropic and beneficent works, which have contributed equally to his fame, and which indicate his real motive of life. Monuments to his generosity are the handsome observatory he gave to Denison University, Granville, Ohio; the science building to the University of Nanking, China; the Young Men's Christian Association Building to the Canton (China) Christian College, the Baptist Ministers Fund, and—as members of the Society recall with pleasure—his generous gift for the inauguration of The Engineering Foundation. These should be supplemented by an account of his establishment of the school of apprentices of The Warner and Swasey Company, and by details of many of his other works of benefaction known only to a few.

One of Mr. Swasey's characteristic traits is his extreme modesty, and the honors that have come to him have certainly not been of his own seeking. In 1900 he was decorated by the French Government with the Legion of Honor for his achievements in the design and construction of astronomical instruments. In 1905 Case School of Applied Science conferred upon him the honorary degree of Doctor of Engineering, and five years later he received the honorary degree of Doctor of Science from Denison University.

MR. SWASEY AT CHINESE ASTRONOMICAL OBSERVATORY ON GREAT WALL OF CHINA

Mr. Swasey's connection with the Society goes back to the beginning, for he was one of the original forty-eight men whom Professor Sweet called to meeting in 1880 for the purpose of taking steps to organize the Society. During his period of membership he has served on numerous committees, including the Executive Committee, the special committee on National Museum, and the John Fritz Medal Committee; he was chairman of the Nominating Committee in 1912. He served as Vice-President of the Society, 1900-1902, and as President during 1904. In the latter capacity he presided at Chicago at the joint meeting of the Institution of Mechanical Engineers of Great Britain and this Society. He entertained the visiting members of the Council of the Institution at a handsome dinner in New York before they started for the meeting and graciously invited the members of the Council of the Society to act with him as hosts. The papers of the meeting were by both British and American authors and were published in the Transactions of both societies.

He presided at the twenty-fifth annual meeting of the Society in New York, 1904. His presidential address was entitled, Some Refinements of Mechanical Science, and discussed the coming of the standards of accuracy of the scientist and instrument maker into the domain of the engineer, the accuracy of mechanical work and measurement involved in graduated limbs of optical apparatus, and the wave length of light as a unit of such mechanical measurement.



SWASEY SPUR GEAR CUTTING MACHINE

WARNER & SWASEY CIRCULAR DIVIDING ENGINE

His first contribution to the proceedings of the Society was made in 1890, when he described a new process for generating and cutting the teeth of spur wheels; the principle of the process was the utilization of a rack as the cutting tool. The machine described was the subject of much comment, to which Mr. Swasey replied that it was simply made to demonstrate the practical solution of a principle, which it did with very satisfactory results. He subsequently contributed discussions to the Transactions upon a variety of subjects, including bevel-gear cutting, microstructure of metals, industrial photography, steam turbines, centrifugal pumps, etc.

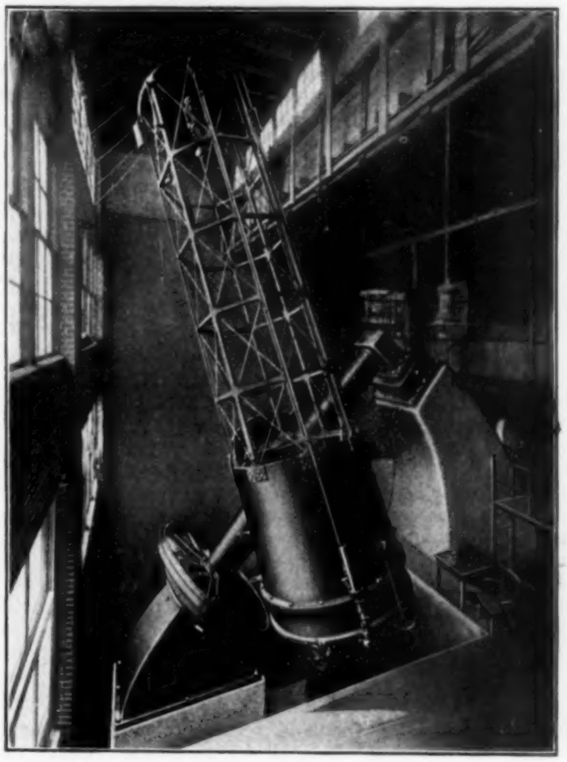
On the occasion of the inauguration of The Engineering Foundation, the President and Trustees of the United Engineering Society tendered a testimonial dinner to Mr. Swasey at the University Club, New York. Those who had the good fortune to be present on that occasion will long remember the overwhelming greeting to him and the pledge to carry out faithfully the trust he had assigned to them.

His connection with other scientific and engineering societies includes membership in the Institution of Mechanical Engineers of Great Britain and in the British Astronomical Society. He is a Fellow of the Royal Astronomical Society and a past-president of the Cleveland Engineering Society. He was a member of the Jury of Awards of the Nashville, the Pan-American, and the St. Louis Expositions, and he was also Vice-President of the Jury of Awards of the Jamestown Exposition.

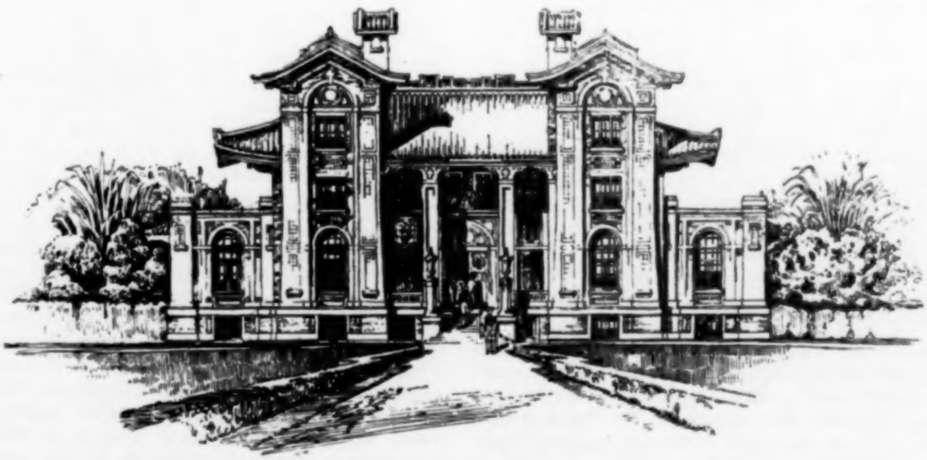
In 1905 he served as President of the Cleveland Chamber of Commerce, and he performed the duties of his position in a most unselfish, intelligent and painstaking fashion. President Roosevelt appointed him a member of the federal commission to test coins in the government mints. In 1907 Mr. Swazey was made first vice-president of the National Board of Trade.

The record of Dr. Swasey's life and attainments well illustrates the remarkable power of one man to rise by force of character, will power and energy, to the highest pinnacle of the profession. Analyzing his methods of living and working, we find them, as in the case of all notable men, remarkably simple. Writing to Prof. M. P. Higgins, member of the Massachusetts Commission on Industrial Education, in reply to a request for his opinion as to the nine essential qualifications of a machine shop foreman, Dr. Swazey specified:

1 Good character and habits
2 Ambition to succeed through meritorious work
3 Adaptability to chosen occupation
4 Studiousness and industry
5 Tidiness in personal appearance and surroundings
6 Faculty for reading and handling men
7 Knowledge and experience in modern machine shop practice
8 Judgment as to amount and quality of work done
9 Resourcefulness in new and improved methods



72-In. Reflecting Telescope by the Warner and Swasey Company



Y. M. C. A. Building, Canton Christian College, Canton, China

qualifications which are so well reflected in his own personality.

It is given to few of us to achieve the wonderful record which Dr. Swasey has attained, but, inspired by him, may we all emulate the best example, as has been his life-long aim.

SOME REFINEMENTS OF MECHANICAL SCIENCE

By Ambrose Swasey

The division of the circle and the measurement of angles has ever been among the unsolved problems of the astronomer, yet in the instruments used by him circles have formed a most important part.

Long before the telescope was invented, Tycho Brahe, the Danish astronomer, "the founder of modern astronomy," constructed for his observatory, instruments of various kinds having graduated circles and arcs of circles. His instruments for the most part were improvements on those used by Arabian astronomers in the eighth and ninth centuries, and these, in turn, were copied after similar instruments used by the Greeks and Egyptians a thousand years previous, and it is supposed that such instruments were used by the Chinese at an even earlier period, so that graduated circles have come down to us from the far-off ages.

The first circular dividing engine was made in 1740 by Henry Hindley, of York, England, for cutting the teeth of clock wheels, and it is interesting to note that in the same year Huntsmann, another clock-maker, of Sheffield, invented the process of making crucible steel, that he might have a metal suitable for the springs of his clocks

Of the several engines constructed later, the one most successful and representing the greatest progress was that made by Ramsden, in 1777. This engine, automatic in its movements, was made especially for graduating circles, and because of the great precision with which he divided the circles of the instruments used by the Government, the Board of Longitude awarded him the sum of six hundred and fifteen pounds. A further and most potent recognition of the excellence of his work lies in the fact that all subsequent circular dividing engines have followed closely the same general principles of construction embodied in the Ramsden engine.

Many excellent dividing engines have been made that are quite sufficient in point of accuracy for the work for which they were intended, but the perfection required in the graduation of circles for astronomical instruments is such that it has been found to be one of the most difficult of all mechanical problems to make an engine to meet such requirements.

In such an engine the chief essential is that the spindle carrying the master-plate shall be as nearly round and as closely fitted in its bearings as is possible, for the degree of excellence with which that work is done determines how closely a circle can be divided.

It seems almost incredible that a well-lubricated spindle of four inches in diameter at its largest part and tapering three-quarters of an inch to the foot, can be made so nearly round and so closely fitted in its bearing that a movement of one-thousandth of an inch in or out of its bearings, will in one case cause it to turn with difficulty, and in the other with perfect freedom, yet this has been found to be within the limits of mechanical refinements.

The greatest accuracy thus for attained in such engines, is one second of arc, which arc, with a radius of three miles, equals one inch, and at twenty inches, which is the radius of the silver ring upon which the graduations on the master-plate are made, a line one-thousandth of an inch in width is equal to twelve seconds of arc, or twelve times the accumulated errors of any number of divisions, or twenty times the greatest error of any single division.

In automatically graduating a circle, it has been found to be impracticable to cut more than six lines in a minute, and it requires about thirty-three hours to divide a circle into two-minute spaces. As with the running of the finest clocks, the best results can only be obtained when the engine is surrounded with every favorable condition possible. Instead of the large circles and sectors used by the ancients, they have been made smaller in diameter as the methods for graduating have been improved, until those of the more modern instruments are seldom more than thirty inches, and some of the latest meridian instruments have circles of but 25 in.

A twenty-five inch circle read with a microscope having a power of forty would be equivalent to a circle of about eighty feet in diameter, and a single second of arc as seen through the microscope would be equal to 0.0024 of an inch, a quantity easily subdivided.

Step by step from the methods of the Arabian astronomers to the time of Tycho Brahe and on down to the present day, improvements in the instruments and methods for the measurement of angles have been going on, until astronomers can measure double stars with a separation of one second of arc, and within less than one second they can define their positions in the heavens.

In the realm of the measurements of minute linear distances, and the perfection of curved and flat surfaces, the refinements are even greater than those pertaining to the measurement of time and of angles.

Most important in the linear dividing engine is the screw, and although much had been accomplished in bringing such engines to a high degree of excellence, it was for Professor Rowland to make an engine which has a practically perfect screw; and without doubt it is in all respects the nearest perfect of all the mechanisms that have been employed for ruling lines exactly parallel and equally spaced.

The Rowland engine was made especially for ruling diffraction gratings which are made of speculum metal, and with it a metal surface has been ruled with 160,000 lines, there being about 29,000 to the inch, and as many as 43,000 lines to the inch have been ruled.

The gratings mostly used have from 14,000 to 20,000 lines to the inch, and with such exactness is the cutting tool moved by the screw that the greatest error in the ruling does not exceed one millionth of an inch.

The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates with surfaces either flat or curved with an error not to exceed one-tenth of a wave length of light, or one four hundred thousandth of an inch.

As the established standards of length, which are the yard of Great Britain and the meter of France, are made of metal, and liable to destruction or damage, Professor Michelson conceived the idea of determining the lengths of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible.

For the purpose of carrying out these experiments, the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

Professors Michelson and Morley devised a method for using the interferometer to make the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Professor Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long intervals, was used for that important work. The final result of the experiments, which occupied nearly a year, shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15 deg. cent. So great is the accuracy of these experiments, that they can be repeated within one part in two millions. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made. These two marvelous instruments, the Rowland dividing engine and the Michelson interferometer, show the possibilities in the perfection of linear divisions and the standards of length.

Abstract of Mr. Swasey's Presidential Address which was published in Vol. XXVI of Trans. Am.Soc.M.E.

WHAT THE SECTIONS HAVE DONE THIS YEAR

LAST month we were able to publish reports from the Sections at Birmingham, Ala.; Buffalo, N. Y.; Cincinnati, O.; Los Angeles, Cal.; New York, N. Y.; Philadelphia, Pa., and San Francisco, Cal., summarizing their activities for the season just closed. Similar reports have since come to hand from the Sections at Chicago, Ill.; Boston, Mass.; New Haven, Conn.; St. Louis, Mo.; Worcester, Mass., and from the Minnesota Section, and are published below.

CHICAGO HAS FOUND DINNER MEETING A SUCCESS

To the Secretary:

We feel that the Chicago Section is about as much alive as any part of the Society. Included in our membership I find the names of some of the ablest engineers in the country, and they all seem to have an interest which is deep and enthusiastic. We had four well attended meetings the past year, at which an average attendance of at least 200 was recorded. It is very difficult to say what technical subjects aroused the greatest interest, as they were all particularly well received. Speaking broadly, however, it would appear that matters relating to power plant design or operation, particularly the combustion part of it, seem to bring out the largest numbers. We apparently struck a happy medium between the social and technical aspects of these meetings. It is not desired to have them entirely one or the other, but a happy combination of both. The dinner which precedes the business affords the opportunity of social intercourse and mutual exchange of ideas. This lasting for an hour or so gives ample opportunity for free discussion and intermingling. By the time the dinner is over we are all ready for the intellectual feast.

We are planning a very similar series for next winter, and it is going to be our endeavor to secure the very highest class of talent for them. There is nothing too big or too good for the Chicago Section, and with the possibility of bringing out three or four hundred engineers of standing, the ablest speaker finds a worthy field for his endeavors.

Joseph Harrington,
Chairman, Chicago Section.

BOSTON ALSO FOSTERS SOCIAL MEETINGS

To the Secretary:

We can only be very enthusiastic over the splendid results obtained in connection with some of our activities during the season just closed. The total attendance of meetings has been much greater than that of any season before.

During the season of 1915-16 we held five meetings, besides three joint meetings and a joint engineers' dinner under the auspices of the Boston Section of the Am.Soc.M.E., and a big joint meeting in Providence with the Providence Association of Mechanical Engineers.

The best attended meeting during the season was the joint meeting at Providence, at which there were over 600 present, with inspection of several of the large manufacturing plants and the laboratories of Brown University, and a dinner at the Narragansett Hotel, at which each person present had telephonic communication with a group of engineers gathered in San Francisco. We had some notable addresses at this meeting,—one on Explosives and the Engineer, by Charles E. Munroe, of George Washington University; also Experience of an Engineer in Public Office, by Morris L. Cooke, Director of Public Works, Philadelphia, and Development of a National Telephone System, by N. C. Kingsbury, vice-president of the American Telephone & Telegraph Company. This was unquestionably the biggest Am.Soc.M.E. meeting ever held in New England.

The next meeting of importance of the season was the seventh Annual Joint Dinner of the three Societies at the Boston City Club, conducted by the Boston Committee of the Am.Soc.M.E. At this there was an attendance of 373. Some able addresses were made in reference to the usefulness of the engineer in connection with the campaign for Preparedness now being waged, and also the engineer's usefulness in case of war.

Two others of our meetings were very largely attended. At one of these Prof. Ira N. Hollis, of the Worcester Polytechnic Institute, presented his paper on Naval Lessons of the Great War for America. The other was the last meeting of the season on May 23, when the subject was: Measurement of Steam Flow to Determine Boiler Output and Measurement of Condition of Fuel Beds. The last mentioned paper doubtless brought out the most discussion of any paper presented during the season. Attendance at each of these meetings was about 150.

The Committee of the Boston Section, together with a Committee from the Boston Society of Civil Engineers and the Boston Section of the A. I. E. E., have had several meetings at which an attempt has been made to secure more coöperation between the different engineering societies, and if possible reduce the total number of engineering meetings held in this community during the season, it being hoped that we might in-so-far as possible pick out subjects for papers in most cases of such general interest that we could have more joint meetings and fewer meetings of the individual sections.

The success of all our meetings at which the social feature has played some part has convinced us that this type of meeting draws the crowd far better than one where we merely present a technical paper and a discussion. This was shown by the large attendance at the joint meeting in Providence, at the joint Annual Dinner, and at the meeting at the Engineers' Club, at which a simple buffet luncheon was served after the discussion. The interest and the attendance were by far the greatest at these three meetings.

The Boston Committee feels very strongly that the important thing to do is to have a few meetings at which we can have a large attendance and an opportunity for social intercourse, believing that such events tend more strongly to up-build and develop engineering organizations than a larger number of meetings which are purely technical in their program.

H. N. Dawes,
Chairman, Boston Section.

SOCIAL AND ENGINEERING ELEMENTS MIXED AT NEW HAVEN

To the Secretary:

The local membership of the New Haven Section has increased nearly fifty per cent recently and interest in the Society was never keener than at present. The coöperation of the Sheffield Scientific School has aided us greatly by providing ideal facilities for meetings and service of its faculty on the Section committee. The heads of the mechanical and electrical engineering departments, Professors Breckenridge and Scott, are members of this Society and much interested in its work. Active student branches are organized in both departments and hold frequent meetings under their own management. Changes in the Section committee are the retirement of Prof. L. P. Breckenridge and Frank L. Bigelow after five years' service and the appointment of their successors, Prof. J. W. Roe of the Sheffield Scientific School and F. L. Mackintosh of the Winchester Repeating Arms Co.

Two meetings have been held during the year with afternoon and evening sessions for reading papers and discussion. About 150 persons attended each meeting and half that number were at the dinner and social hour between sessions. The registration showed that half the attendance consisted of nonmembers, and many were present from neighboring cities, Bridgeport, Waterbury, New Britain and Hartford. The spring meeting was a joint one with the civil, electrical and mining engineers of this city.

Four additional informal meetings for members only have been held, with an average attendance of twenty. One meeting was a noonday luncheon at the Hotel Taft, the others were evening meetings with a brief talk by one of the members.

The last meeting, June 29, was held in the Mason Laboratory, when P. J. G. Reuter gave an interesting talk on the Diesel Motor, with pictures of Swiss machine shops where

the machines are built. The interest in the monthly meetings shows the possibility of continuing them during the summer, and another has been planned for July.

The new feature of the year has been the monthly meeting with combined social and engineering elements that promise well for the future. The committee of the New Haven Section is H. B. Sargent, *chairman;* Prof. E. H. Lockwood, *secretary;* J. Arnold Norcross, Prof. J. W. Roe, and F. L. Mackintosh.

E. H. Lockwood,
Secretary, New Haven Section.

MINNESOTA'S EXPERIENCES AND PLANS

To the Secretary:

In reviewing the work of the Minneapolis Section of the past year, the questions of policy for future action naturally resolve themselves into specific classes; for instance, how to increase our active membership, to make the section a more potent force in the State, to be of greater value to the members in their varied lines of specialized work, and to promote a higher standard of engineering ethics.

Suitable material for membership is not wanting, but the principal difficulty in enlisting local engineers in the Am. Soc. M. E. is due to the number of local engineering activities to which they already subscribe, and a reluctance to assume further financial obligations or to withdraw from obligations already incurred. A more active canvass for the coming year will be necessary.

The Section realizes that it can profitably lend itself to any progressive plan to increase its value to the State, and willingly holds joint sessions with other engineering societies. We have representation in the Minnesota Joint Engineering Board, an organization which has as its object the promotion of engineering interests in the State.

The meetings of the past year have not been as well attended as the character of the papers presented would warrant. The topics discussed in the papers covered a wide range of engineering work.

A symposium on Gas Engines requiring both afternoon and evening sessions was very successful, and it is the intent to have a similar session during the coming year, featuring some other line of work.

The dinner dance was the big social event of the year, and it served as an occasion to invite the participation of engineering friends and wives and sweethearts of the members. This feature will be repeated.

Occasionally a meeting is preceded by a luncheon, which permits of closer contact of members and is conducive to a free interchange of ideas.

We have access to moving picture machines, which have been used to present papers requiring their use and to present films of a less serious character.

Located as we are a long way from New York, there seems to be a lack of close contact with headquarters, a condition which I believe will be largely mitigated by the annual visit of the President. It is hoped that we may be able to get other men of large caliber to visit us and leave a message, both stimulating and inspiring. We also hope to have all local papers prepared either in full or in abstract to be distributed prior to their presentation, so that a fuller discussion of them may be had.

John V. Martenis,
Chairman Minnesota Section.

ST. LOUIS PLANS TO INCREASE ITS MEMBERSHIP

To the Secretary:

Our meetings of the present year differed from those of last year in better attendance, more social meetings, scarcity of local papers, and a wide interest in military topics.

The meeting in October when Dr. Brashear was our guest was of such an epochal nature as to put it in a class by itself. Dr. Brashear's lecture was, of course, the largest meeting we have held. In fact, we rather think it is a record-breaker for any engineering meeting in this City. The attendance was over 1,200.

Mr. Carl Barth's paper in January drew forth quite a crowd, with probably an attendance of about 125.

On account of our relations with the Engineers' Club of this City, it is a little hard to say specifically what kind of a meeting draws the best. A first class paper at the Engineers' Club will bring about seventy to one hundred at any time, although the proportion of this attendance that represents the Am.Soc. M.E. depends very largely on the nature of the paper, whether mechanical, electrical, etc. The attendance of strictly Am.Soc. M.E. men is generally better at the social meetings than at any one of the joint meetings just mentioned. The Am.Soc. M.E. turns out very well at any one of the trips to surrounding plants, such as the one to the St. Louis Plate Glass Works last summer.

The freest and best discussions come out at social meetings, where 90 per cent of the members are Am.Soc.M.E. men, and the topics are of more specific interest. At such meetings there is no professional paper, but a talk of general interest is given by someone outside of the Society and a discussion of this almost always drifts into a technical discussion.

For next year, the new board has in mind the following features:

An increase in social meetings
One, if not two, local technical papers
Several interesting industrial trips
Greater activity in securing new members.

The following suggestions are made to you at headquarters: You could keep us better posted as to the election of new members and inform us more quickly of movements of members to or from this Section.

At social meetings more effort should be put forward to really make the men acquainted. We ought to have badges of some kind, having letters not less than 3/8 in. high, giving the name and firm to which connected.

The members should not only be introduced, but at dinners they should be arranged in groups of not over six at a table, and further care should be taken that at different meetings different groups will seat at the same table. We find this a much better arrangement than seating all of the members at one large table.

You could send us some suggestions regarding making up a new executive committee. As now arranged here, the two previous chairmen automatically become members of the new committee and three new members are elected. The two ex-chairmen are not eligible for office on the new committee. We believe that such a committee should not have over five members, but for many reasons it would be very desirable to have the past Secretary on this new committee, as at present the succeeding Secretary has to feel his way for some months, getting little help from the retiring Secretary.

We regret very much that we have no special programs or circulars to send you, other than such as have already been sent covering the October meeting, when Dr. Brashear was present. While these invitations were not unique, they certainly were successful in performing their function in drawing a record attendance.

George R. Wadleigh,
Secretary, St. Louis Section.

WORCESTER'S FIRST YEAR A SUCCESS

To the Secretary:

Regarding the work of the Worcester Section for the season just concluded, this was our first year and only two meetings were held. The first in the fall was addressed by Frank B. Gilbreth on Motion Study for Crippled Soldiers and was held at Worcester Polytechnic Institute. Attendance about 125.

Our second meeting was combined with a dinner at the Hotel Bancroft and was addressed by Dr. Ira N. Hollis who spoke on What Constitutes a Well Rounded Fleet. The attendance this evening was a little over 200 and was a very enthusiastic meeting.

Our local Committee was reelected for another season. We have placed before many local engineers, membership literature and have met with a number of favorable replies. I regret that exact figures are not available as I write to show the net increase in membership for the section but believe it is

a sound and healthy growth coming from the individual rather than from the efforts of pressure by the Committee.

We feel that our expenditures have been small considering that we are maintaining a mailing list of upwards of 1,000 names.

E. Howard Reed,
Chairman, Worcester Section.

TRIBUTE TO DR. E. D. LEAVITT

The special committee, consisting of C. T. Main, A. M. Mattice, appointed by the Council to prepare resolutions upon the death of Dr. Erasmus Darwin Leavitt, Past President and Honorary Member, has drafted the following:

RESOLUTIONS UPON THE DEATH OF DR. E. D. LEAVITT

The Council desires to express its profound sorrow at the death of its past President and Honorary Member, Dr. Erasmus Darwin Leavitt, which occurred on March 11, 1916.

In Dr. Leavitt's death the engineering profession and the Society lost a pioneer in the study of economical and high-class steam engineering, and an engineer of rare insight and judgment in general mechanical construction. Without special preliminary and technical instruction, the advantages of which nearly all engineers of the present day possess, he was able to work into the mysteries of the behavior of steam and the properties of materials, and through his own unaided efforts became skilled in theoretical and technical matters. No mechanical engineer has left for our contemplation more impressive monuments of human skill than he.

The Society owes to Dr. Leavitt a special debt of gratitude for his efforts in its foundation.

In pumping engine design Dr. Leavitt, for a time, was almost the sole occupant of the profession in the best productions. He took up steam economy where it was left by the Cornish engine and carried it on, step by step, to almost its present state, and in the application of sound principles, propriety of design and excellence of form, he was unsurpassed. Dr. Leavitt was able to carry on this work in spite of some delicacy of health.

There are few of his contemporaries in the Society now living, but they and the younger members who knew him will miss his unfailing courtesy.

The Council of The American Society of Mechanical Engineers hereby places this resolution upon its records, and sends a copy to his family and to affiliated associations.

ALFRED NOBLE MONUMENT

Congress has granted a site for a monument to be erected as a memorial to the late Alfred Noble, Past President of the American Society of Civil Engineers and of the American Institute of Consulting Engineers, and Past Vice-President of this Society and member of the Council at the time of his death, which occurred April 18, 1914.

The location selected is opposite the new building of the Department of the Interior, on New York Avenue, Washington, D. C. The preliminary designs are in the hands of a sculptor, and the committee having the matter in charge expects to report as soon as possible on the design chosen.

There are many monuments to statesmen and soldiers, and but few to engineers, consequently this will be an opportunity to which engineers should enthusiastically respond.

ENGINEER SECTION OF OFFICERS RESERVE CORPS

The engineers of the country will be fully alive to the opportunity for national service afforded by the passage of the Army Reorganization Act, which became law on July 1, and which provides for an Engineer Section of the Officers Reserve Corps.

The Act avoids any specific mention as to how the organization of the Engineers Section is to be carried out, this matter being left to the War Department. Meanwhile, General Black has requested the Joint Committee of the National Engineering Societies on the Organization of a National Engineer Reserve to recommend for local boards of examiners civilian engineers in each district, representing the civil, mechanical, electrical, and mining engineering professions, such engineers to serve with the officers of the Corps of Engineers in recommending candidates for appointment to the Officers Reserve Corps.

For the purpose of supplying to those interested full and complete information as to the requirements for commissions in the several grades, including Second Lieutenant, Lieutenant, Captain and Major, and for Master Engineers and Sergeants, and the method of procedure to secure commissions or enlistment, it is proposed to divide the country into twenty-eight districts, with headquarters in each district.

It is hoped that in the next issue we may be able to give complete information.

ENGINEERING RESEARCH STATIONS

Of special interest to engineers is the Newlands bill for establishing experiment stations in engineering, corresponding to the existing agricultural experiment stations, in the land grant colleges.

The land grant colleges and their agricultural experiment stations have been of value not only to agriculture, but to education in the several states locally and to the nation. They have as well assisted in the establishment of the state universities as a thoroughly useful element in any community and correspondingly increased the respect of the people for the college. The land grant colleges and the institutions of which they are a part received in 1914 from the United States $2,500,000, and from the states and from other sources over $30,000,000. They have 9,000 instructors and 105,000 students.

By the Hatch act of 1887 and the Adams act of 1906 the sum of $30,000 a year in each state is appropriated for research in agriculture in the experiment stations. On the other hand, the colleges have more students of mechanic arts than of agriculture, but there is no provision for research in the mechanic arts and engineering, and the sciences, such as physics and chemistry, on which they are based. The plan is that research in the engineering sciences will now be equally encouraged by the passage of the Newlands bill, which appropriates $15,000 to each state and territory for conducting investigations in engineering and publishing the results.

As a result of the greater service which agricultural departments render, their prestige is greater than the engineering departments. Further, by the lack of appropriations for the engineering departments the standing and state of development is not only below that of the agricultural departments in the same colleges, but is below the standard of other engineering colleges.

There is a difference of opinion as to just how to accomplish this improvement, but there can be no doubt of the necessity of bringing up the standing of the engineering departments of the land grant colleges.

An Am.Soc.M.E. sub-committee on Increase of Membership has been established for the State of Tennessee. Eugene C. Patterson of Chattanooga has been appointed chairman.

Lucien Buck has been appointed chairman of the Rochester, N. Y., sub-committee on Increase of Membership, succeeding John C. Parker.

ROLL OF HONOR

THE Society is desirous of publishing lists of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Navy, or in any other capacity in the services of the country. Every member who is, or who knows of any other member who is, engaged in the service of the country is requested to notify the Secretary. In response to the announcement in this regard in the July issue of The Journal, the following names have been received:

ADDICKS, LAWRENCE, Member Naval Consulting Board
BALL, BERT C., Oregon State Director, Committee on Industrial Preparedness, Naval Consulting Board
BEERS, R. L., Assistant Fuel Engineer, U. S. Bureau of Mines, Pitts-Pittsburgh, Pa.
BEHR, F. J., Captain, Coast Artillery Corps, U. S. A., Fort Monroe, Va.
BERGEY, J. E., Leadingman Draftsman, Machinery Division, Navy Yard Bldg., Philadelphia, Pa.
BILLMYER, CARROLL D., Corporal, First Company, Coast Artillery Corps, National Guard of Virginia
BIRNIE, ROGERS, Colonel, Sandy Hook Proving Ground, Fort Hancock, N. J., and Governor's Island, N. Y.
BUYERS, A. S., Second Lieutenant, Coast Artillery Corps, U. S. A., Adjutant, Fort Jay, Governor's Island, N. Y.
CARLSSON, CARL A. V., Ordnance Engineer, Navy Yard, Washington, D. C.
CARPENTER, R. C., Mississippi State Director, Committee on Industrial Preparedness, Naval Consulting Board
CHADWICK, GEORGE A., Leading Ordnance Draftsman, U. S. Naval Gun Factory, Washington, D. C.
CHANDLER, R. E., Florida State Director, Committee on Industrial Preparedness, Naval Consulting Board
CHARLES, L. J., New Mexico State Director, Committee on Industrial Preparedness, Naval Consulting Board
COBURN, FREDERIC G., Naval Constructor, Construction Corps of the U. S. Navy, Boston, Mass.
COFFIN, HOWARD E., Member Naval Consulting Board
COKER, J. L., JR., South Carolina State Director, Committee on Industrial Preparedness, Naval Consulting Board
COLE, WINTHROP, Mechanical Engineer, Engineering Experiment Station, U. S. Naval Academy, Annapolis, Md.
CONTI, ANGELO, Chief Computing Draftsman, Bureau of Steam Engineering, Navy Department, Washington, D. C.
COOKE, STANLEY S., Private, Troop D, 1st Squadron Cavalry, Colorado National Guard
COYLE, A. M., Mechanical Engineer, Coast Defense, Board of Engineers, U. S. A.
CROCKARD, F. H., Alabama State Director, Committee on Industrial Preparedness, Naval Consulting Board
CROUCH, CALVIN H., North Dakota State Director, Committee on Industrial Preparedness, Naval Consulting Board
CURTIS, GREELY S., Lieutenant, Junior Grade, 10th Deck Division, Massachusetts Naval Militia
DAVIDSON, M. W., South Dakota State Director, Committee on Industrial Preparedness, Naval Consulting Board
DE BAUFRE, WILLIAM L., Mechanical Engineer, U. S. Naval Engineering Experiment Station, Annapolis, Md.
DIAMOND, GEORGE A., Alaska Director, Committee on Industrial Preparedness, Naval Consulting Board
DICKIE, G. W., California State Director, Committee on Industrial Preparedness, Naval Consulting Board
DOTY, PAUL, Commissary General, with rank of Brigadier General, Minnesota National Guard, St. Paul, Minn.
DOW, ALEX, Michigan State Director, Committee on Industrial Preparedness, Naval Consulting Board
EDISON, THOMAS A., Chairman, Naval Consulting Board
ELSAS, OSCAR, Georgia State Director, Committee on Industrial Preparedness, Naval Consulting Board
EMMET, WILLIAM L. R., Member, Naval Consulting Board
FISHER, F. P., Oklahoma State Director, Committee on Industrial Preparedness. Naval Consulting Board
FLAD, E., Missouri State Director, Committee on Industrial Preparedness, Naval Consulting Board
FLAGG, SAMUEL B., Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
FLATHER, J. J., Minnesota State Director, Committee on Industrial Preparedness, Naval Consulting Board
FRY, THOMAS W., New Hampshire State Director, Committee on Industrial Preparedness, Naval Consulting Board
GANTT, H. L., New Jersey State Director, Committee on Industrial Preparedness, Naval Consulting Board
GARDNER, WILLIAM M., Assistant Engineer, U. S. Engineer Office, Memphis, Tenn.
GILLIS, H. A., Committee on Engineer Reserve Corps
GLADFELTER, HERBERT S., Junior Mechanical Engineer, U. S. Engineer Office, Memphis, Tenn.
GOSS, DR. W. F. M., Illinois State Director, Committee on Industrial Preparedness, Naval Consulting Board
GURNEY, DAYTON A., Draftsman, Charge Field Carriage Div., Ordnance Office, U. S. A.
HAMMETT, P. M., Maine State Director, Committee on Industrial Preparedness, Naval Consulting Board
HARTNESS, JAMES, Vermont State Director, Committee on Industrial Preparedness, Naval Consulting Board.
HOEFER, E. G., Wyoming State Director, Committee on Industrial Preparedness, Naval Consulting Board
HOLLIS, IRA N., Massachusetts State Director, Committee on Industrial Preparedness, Naval Consulting Board
HOLMES, URBAN T., Commander, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.
HOOD, OZNI P., Chief Mechanical Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
HUMPHREYS, ALEX. C., Committee on Engineer Reserve Corps
HUNT, ANDREW M., Member, Naval Consulting Board
HUNT, LEIGH, Lieutenant, Machine Gun Company, 1st Kansas Infantry, Eagle Pass., Texas.
IRELAND, MARK L., Captain, Coast Artillery Corps, U. S. A., Fort Greble, R. I.
JENKS, GLEN F., Major, Ordnance Dept., U. S. A., Manila Ordnance Depot, Manila
JOHNSON, ARTHUR E., Designer, Ordnance Office, War Department, Washington, D. C.
JOHNSON, THEODORE W., Professor Mathematics, U. S. N., U. S. Naval Academy, Annapolis, Md.
KENNEDY, JULIAN, Pennsylvania State Director, Committee on Industrial Preparedness, Naval Consulting Board
KENNEY, LEWIS H., Draftsman-in-Charge, Machinery Div., Navy Yard, Philadelphia, Pa.
KINGSTON, ARTHUR, Lieutenant, U. S. Marine Corps, Marine Barracks
KREISINGER, HENRY, Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
LAWATSCH, FRANK R., Ordnance Draftsman, Sandy Hook Proving Ground
LEE, WILLIAM S., North Carolina State Director, Committee on Industrial Preparedness, Naval Consulting Board
LEWIS, WILFRED, Committee on Engineer Reserve Corps
LOCKETT, A. M., Louisiana State Director, Committee on Industrial Preparedness, Naval Consulting Board
McGREGOR, A. G., Arizona State Director, Committee on Industrial Preparedness, Naval Consulting Board
McKEEN, WM. R., Nebraska State Director, Committee on Industrial Preparedness, Naval Consulting Board
MARSHALL, W. H., New York State Director, Committee on Industrial Preparedness, Naval Consulting Board
METZ, WALTER R., Supt. of Buildings, Government Printing Office, Washington, D. C.
MILLER, SPENCER, Member, Naval Consulting Board
MOUNT, W. D., Virginia State Director, Committee on Industrial Preparedness, Naval Consulting Board
NORDBERG, C. V., Montana State Director, Committee on Industrial Preparedness, Naval Consulting Board
NORTON, HAROLD P., Captain, U. S. N., Mem. Naval Examining and Retiring Boards, Navy Yard, Washington, D. C.
OSGOOD, WENTWORTH H., Ensign, U. S. N., U. S. S. Nevada
PELOT, JOSEPH H., Captain, Ordnance Dept., U. S. A., Frankford Arsenal, Philadelphia
PATERSON, JAMES V., Washington State Director, Committee on Industrial Preparedness, Naval Consulting Board
POTTER, A. A., Kansas State Director, Committee on Industrial Preparedness, Naval Consulting Board
QUINLIVAN, OSWALD, Mechanical Engineer, U. S. Engineer Office, Albany, N. Y.
RAYNAL, ALFRED H., Mechanical Engineer, Bureau of Steam Engineering, Navy Department, Washington, D. C.
REED, CHARLES M., Engrg. Observer, U. S. Naval Engrg. Exper. Sta., Annapolis, Md.

REED, JAMES, JR., Naval Constructor, U. S. N., Mare Island Navy Yard, Vallejo, Cal.
RIKER, ANDREW L., Member Naval Consulting Board
RITTENOUR, FREDERICK H., Draftsman, Department Marine Engineering and Naval Construction, U. S. Naval Academy, Annapolis, Md.
ROCKWOOD, GEORGE O., Indiana State Director, Committee on Industrial Preparedness, Naval Consulting Board
RUSSELL, JAMES GORDON, Instructor Mechanical Engineering, Post Graduate Department, U. S. Naval Academy, Annapolis, Md.
SANDERS, NEWELL, Tennessee State Director, Committee on Industrial Preparedness, Naval Consulting Board
SANDSTROM, C. O., Captain, Company L., 3rd Regiment, Mo., Laredo, Texas.
SARGENT, H. B., Connecticut State Director, Committee on Industrial Preparedness, Naval Consulting Board
SAUNDERS, WILLIAM L., Second Vice-Chairman, Naval Consulting Board
SCOTT, FRANK A., Ohio State Director, Committee on Industrial Preparedness, Naval Consulting Board
SCRUGHAM, JAMES G., Nevada State Director, Committee on Industrial Preparedness, Naval Consulting Board
SHARPE, HENRY D., Rhode Island State Director, Committee on Industrial Preparedness, Naval Consulting Board
SMEALLIE, JOHN M., Lieutenant, U. S. N., Navy Yard, Brooklyn, N. Y.
SMITH, CARL D., Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
SMITH, R. W., Delaware State Director, Committee on Industrial Preparedness, Naval Consulting Board
SMITH, WILLIAM WALKER, Lieutenant, U. S. N., Pittsburgh, Pa.
SPEED, W. S., Kentucky State Director, Committee on Industrial Preparedness, Naval Consulting Board
SPERRY, ELMER A., Member, Naval Consulting Board
STEARNS, T. B., Colorado State Director, Committee on Industrial Preparedness, Naval Consulting Board
STEEL, REGINALD A., Corporal, Company A, 22nd Corps of Engineers, National Guard, New York
STRATTON, S. W., District of Columbia Director, Committee on Industrial Preparedness, Naval Consulting Board
STROTHMAN, L. E., Wisconsin State Director, Committee on Industrial Preparedness, Naval Consulting Board
STUART, MILTON C., Mechanical Engineer, U. S. Naval Engineering Experiment Station, Annapolis, Md.
SWIFT, JOHN B., Lieutenant, Company E, 1st Battalion, Illinois Engineers
TAYLOR, L. B., Torpedo Engineer, U. S. Naval Torpedo Station, Newport, R. I.
THOMAS, C. C., Maryland State Director, Committee on Industrial Preparedness, Naval Consulting Board
TUTTLE, W. B., Texas State Director, Committee on Industrial Preparedness, Naval Consulting Board
VOORHEES, ALBERT C., Draftsman, Charge Government Division, California Shipbuilding Co.
WADDELL, GEORGE F., Idaho State Director, Committee on Industrial Preparedness, Naval Consulting Board
WARD, CHARLES E., West Virginia State Director, Committee on Industrial Preparedness, Naval Consulting Board
WESTERVELT, W. I., Major, Ordnance Department, U. S. Government, Sandy Hook Proving Ground, Fort Hancock, N. J.
WILEY, WM. H., Chairman, Committee on Engineer Reserve Corps
WILSON, B. N., Arkansas State Director, Committee on Industrial Preparedness, Naval Consulting Board
WOOD, HORATIO N., First Lieutenant of Engineers, U. S. Coast Guard, U. S. Cutter Morrill, Detroit, Mich.
WOODWARD, S. M., Iowa State Director, Committee on Industrial Preparedness, Naval Consulting Board
WRAITH, WILLIAM, Utah State Director, Committee on Industrial Preparedness, Naval Consulting Board

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

ANNOUNCEMENTS

Ralph W. Bunge has become associated with the Wm. H. Bunge Company, Chicago, Ill.

Lester G. French, editor of The Journal, has recently undergone a severe operation, but is now out of danger and is recovering rapidly.

Dennis J. O'Brien has assumed the duties of assistant superintendent of power of the New Orleans Railway and Light Company, New Orleans, La.

Holden A. Evans, formerly vice-president and general manager of The Baltimore Dry Docks and Ship Building Company, was elected president of the company on June 1.

George T. Snyder, formerly chief engineer at the National Tube Company, McKeesport, Pa., has been transferred to a similar position at the Lorain Works of the Company at Lorain, O.

Henry G. Stott, superintendent of motive power, Interborough Rapid Transit Co., New York, has recently undergone a severe operation. According to the latest report, he is recovering rapidly.

Louis E. Strothman, manager and chief engineer of the pumping department of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., was recently elected president of the Engineers' Society of Milwaukee.

Frank L. Allen, representative of The Landis Tool Company, Waynesboro, Pa., has been elected secretary-treasurer and member of the Board of Directors of the Dugger Motor Sales Company of Indianapolis, Ind.

Joseph H. Pound, instructor in charge of mechanical engineering, Rice Institute, Houston, Tex., is assisting with the plans for increasing the capacity of the plant of the Houston Lighting and Power Company.

Reginald Trautschold, who has specialized in the power plant field for a number of years, is the winner of the second prize of $25 offered by the Diamond Power Specialty Company for the best papers on mechanical soot blowers.

H. Kenyon Burch, chief engineer of the Inspiration Consolidated Copper Company, has completed his work pertaining to the design and construction of the plant, and left on July 1 for an extended vacation trip throughout the East.

Walter N. Polakov, recently superintendent of power of the N. Y., N. H. & H. R. R., and consulting engineer to the Board of Estimate and Apportionment of the City of New York, is now directing the foreign-trade engineering work of David Vershbinsky, Inc., New York.

CHANGES OF POSITION

Ralph W. Bingaman, formerly engineer with the Communipaw Steel Company, New York, has become associated with the Morris Iron and Steel Company, New York.

Rhea H. Robinson has become affiliated with L. V. Estes, Inc., Chicago, Ill. He was until recently in the employ of the Economy Fuse Company of the same city.

W. Doke Scott, formerly engineering assistant with the Syracuse Lighting Company, Syracuse, N. Y., has become affiliated with the New Haven Gas Light Company, New Haven, Conn.

Henry W. Crowell, formerly connected with the Eureka Air Compressor Company, Inc., Montclair, N. J., has accepted a position with the Otis Elevator Company, New York, N. Y.

Frank L. Cocks, formerly connected with Arbuckle Brothers, in the capacity of special machine designer, has become identified with the Obex Laboratories, Marietta, Ohio, as superintendent.

Ernest B. Nelson, formerly in the employ of the Chile Exploration Company, Chuquicamata, Chile, S. A., has become associated with the Andes Exploration Company, Chanaral, Chile, S. A.

William H. Gillam, Jr., has resigned his position as superintendent of James Boyd and Brothers, Inc., Philadelphia, Pa., to accept a position with the Scott Paper Company of the same city.

James F. Cyphers has resigned his position as supervising engineer of Merck and Company, Rahway, N. J., to become mechanical superintendent of the Eagle Rock Manufacturing Company, Verona, N. J.

Paul E. Good, formerly connected with the Southwark Foundry and Machine Company, Philadelphia, Pa., as mechanical engineer, has accepted a position with the Rateau Battu Smoot Company of New York.

Parker M. Robinson, until recently associated with Yale University, New Haven, Conn., has accepted an industrial management position with H. L. Gantt, and is located at The Celluloid Company, Newark, N. J.

Laurence Meharg has resigned his position of mechanical engineer with the Allis-Chalmers Manufacturing Company, Philadelphia, Pa., and has accepted a position with the Hazel-Atlas Glass Company, Washington, Pa.

George S. Wheatley, instructor of mechanical engineering, University of Pennsylvania, Philadelphia, Pa., has become associated with the Cambria Steel Company, Johnstown, Pa., in the steam engineering department.

John W. Morton has assumed the duties of chief draftsman of the Baltimore Oil Engine Company, Baltimore, Md. He was formerly connected with the designing department of the McIntosh & Seymour Corporation, Auburn, N. Y.

Henry W. Johnson has resigned his position as efficiency engineer with the Russell, Burdsall and Ward Bolt and Nut Company, Port Chester, N. Y., to accept the position of superintendent of the Putnam Machine Company of Fitchburg, Mass.

Conrad R. Adams has resigned his position of assistant engineer with the Chandler Motor Car Company, Cleveland, O., and has become connected with the Sibley Machine Tool Company, South Bend, Ind., in the capacity of factory manager.

Henry O. Pond has resigned as mechanical engineer of Westinghouse, Church, Kerr and Company, to take charge of the timber, pulp and water power interests in the northwest of E. B. Cadwell and Company, Inc., with offices at 25 Broad Street, New York.

Burt H. Weston, formerly instructor in mechanical and engineering drawing and design in The David Ranken, Jr., School of Mechanical Trades, St. Louis, Mo., has severed his connection with the school and has opened an office in Dayton, O., where he will conduct the business of consulting and equipment engineer. Mr. Weston is the inventor and patentee of a disk valve for internal combustion engines.

APPOINTMENTS

O. C. Skinner has been appointed superintendent of the Standard Steel Works Company, Burnham, Pa.

A. L. Hoerr, steam and hydraulic engineer of the National Tube Company, McKeesport, Pa., has been appointed chief engineer at the National works to succeed George T. Snyder.

E. J. Burdick has been appointed assistant general manager of the Detroit United Railway. Mr. Burdick has been engaged in operating work with the company and its predecessors for the past thirty years.

George W. Fuller has been appointed special lecturer on sanitary engineering (sewage disposal) at Sheffield Scientific School, Yale University, New Haven, Conn. Mr. Fuller has also been made supervising engineer of the operation of the sewage-disposal tank at York, Pa.

L. H. Mesker, formerly in charge of the Ohio territory of Kearney and Trecker Company, Milwaukee, Wis., has been appointed sales manager of the company, with headquarters in Milwaukee. He will have complete charge of the sales department and will also retain supervision over the Ohio territory through the Cleveland office.

AUTHORS OF PAPERS, ETC.

Thomas T. Eyre is the author of a paper entitled Effect of Early Cutoff on Wiredrawing which appears in a July issue of *Power*.

Cloyd M. Chapman has contributed a brief article on Strength the Essential in Concrete Aggregates to the July 8 number of *Engineering Record*.

Dr. John A. Brashear delivered an address on the attitude of science to engineering at the June 27-30 convention of the American Society of Civil Engineers in Pittsburgh, Pa.

NECROLOGY

GEORGE MEREDITH PEEK

George Meredith Peek was born at Richmond, Va., on September 29, 1870. He received his preparatory education in the home schools and at the age of 16 began his business life as an apprentice in the machine shop of the Baltimore & Ohio Railroad at Baltimore. In 1888, as traveling electrician for the Baxter Electric Motor Company, he had charge of their exhibit at the Milwaukee Industrial Exposition. From 1888 to 1891 he was engaged in machine work and general drafting with the Richmond Locomotive Works and also in the drawing room of the Newport News Shipbuilding and Dry Dock Company.

In 1890, Mr. Peek entered the University of Virginia at Charlottesville, as a student. He remained at the University for six years, during which period he received degrees in both mechanical and civil engineering and became an instructor under Prof. William H. Thornton. From 1896 to 1898 he occupied the chair of Civil and Mechanical Engineering at the University of Arkansas.

After this extended period of study, he engaged in consulting work for a year and then entered the employ of the Pelton Water Wheel Company in New York as engineer, designing and installing water power plants. While with this company he designed and installed plants in the United States, Mexico, Canada and Spain, pre-eminent among which were the Animos Power Plant in Colorado and the power plant for the Companie General de Asfeltos y Portlant in Spain. Mr. Peek also designed the motive power equipment of the Niagara Falls pumping plant and designed and erected the regulating apparatus.

In 1910 he entered the employ of the St. Louis Water Department and devoted his energies to many improvements in the service. He was appointed engineer-in-charge of the construction branch, which position he held up to the time of his death which occurred on May 2, 1916.

Mr. Peek became a member of the Society in 1892.

CHESTER BIDWELL ALBREE

Chester Bidwell Albree was born at Allegheny, Pa., on April 8, 1862. He received his preparatory education in the Western University of Pennsylvania and his technical education at the Worcester Polytechnic Institute in Massachusetts, from which he graduated with the degree of B. S. in 1884. Following his graduation Mr. Albree spent a year in travel, visiting manufactories in various cities, and selling lubricating oils. Before entering into business with his father, he worked in the drawing room at Thomas Carlin's Sons in Allegheny.

The remainder of his business life was spent in establishing and managing The Chester B. Albree Iron Works.

While his principal business was ornamental iron, Mr. Albree started to manufacture pneumatic compression riveters in 1900, and did all the designing of these machines himself. He originated the very successful universal bail, whereby a suspended machine may be turned in any position by merely swinging it through a bail, so constructed as to keep always the center of gravity of the machine at the same height, and thus preserve stable equilibrium. Among his other valuable patents was one covering an automatic pneumatic compression riveter which does away with the adjustment screw entirely. He was widely known as a manufacturer and designer of bridge railing, and many of his beautiful designs can be seen in all parts of the United States.

Mr. Albree was a past president of the Engineers' Society of Western Pennsylvania and a member of the American Association for the Advancement of Science. He became a member of this Society in 1886. He died on May 27, 1916.

DON JUAN WHITTEMORE

Don Juan Whittemore was born at Milton, Vt., on December 6, 1830. After his graduation from the Bakersfield Academy, Mr. Whittemore joined the engineering staff of the Vermont Central Railway, later going with the Western Railway of Canada and the Central Railway of Ohio.

Mr. Whittemore became chief assistant engineer of the La Crosse & Milwaukee Railroad, where he served for four years, and was then made chief engineer of the Southern Minnesota Railway and assistant chief of the Western Railway of Cuba. He later returned to the La Crosse & Milwaukee Railroad and in 1863, became connected with the Chicago, Milwaukee & St. Paul Railroad, where he remained until 1910, retiring as consulting engineer of the road.

Mr. Whittemore was a past president of the American Society of Civil Engineers, and had received the degree of C. E. from the University of Vermont and those of Ph. D. and LL. D. from the University of Wisconsin.

He became a member of the Society in 1889. He died at his home in Milwaukee on July 17, 1916.

WILLIAM A. WARMAN

William A. Warman was born at Latrobe, Jackson Co., Ohio, on June 28, 1861, and received his education at the home schools. From 1878 to 1886 he devoted his time to developing inventions and following this he had six years' shop experience in various western railroad shops. From 1892 to 1894 he was connected with the Rodwell Co., of Buffalo, and the following year he managed a shop of his own at Niagara Falls. In 1898 he was engaged by the Buffalo Metal Manufacturing Co., and from 1898 to 1901 he held a position with the Ritter Dental Company. During 1902 and 1903 he was with the Dieks Press Guard Manufacturing Company, and became a pioneer in the development of press guards for stamping presses. In 1904 he worked for the American Tobacco Company and in 1905 formed the Warman Company, which soon thereafter consolidated with the Keller Mechanical Engraving Company. With this concern he held the position of designer of special machinery. He also did much original research work in connection with internal combustion engines and gas turbines until the time of his death.

Mr. Warman was the inventor of a number of safety devices, also of the hollow set screw. He became a member of the Society in 1908. He died on July 2, 1916.

Professor Ernest Mach recently died in Munich, Germany, at the age of 78. His treatises on Mechanics and The Theory of Heat have long since become classics. Just before his death he completed a book on The Principles of the Theory of Light, as a companion volume to the two former books. The works of Dr. Mach have been noted for the broad spirit in which they treated complicated problems of physics, and for the interesting investigations of the historical development of theories of physical phenomena.

There is now being inserted in the pages of the Advertising Section of The Journal each month (See p. 57 this month) a Card Index summarizing the contents of The Journal for the preceding month. A facsimile of this index appears below. Members may clip this out of the Advertising Section and paste it on a card for use in their files.

The Journal of The American Society of Mechanical Engineers

July, 1916 CARD INDEX Vol. 38, No. 7

The Illuminating Engineering Society will hold its annual convention in Philadelphia, September 21 to 28.

Following the convention, a course of lectures on illuminating engineering will be given under the joint auspices of the society and the University of Pennsylvania, at the University. Associated with the lectures will be an exhibition showing the latest developments in illuminating appliances and novel applications of light. R. H. Fernald, Mem. Am. Soc. M. E., is a member of the University Committee in charge of participation.

The executive committee of the Board of Supervising Inspectors of the United States Steamboat-Inspection Service has adopted a rule eliminating the requirements for reduction of area of steel boiler plate, pending an investigation by the U. S. Bureau of Standards. The amendment was approved by the Secretary of Commerce on June 7, 1916.

The requirements referred to and which were eliminated were contained in the first paragraph of Section 5, Rule 1, General Rules and Regulations of the Board of Supervising Inspectors. The paragraph as amended reads as follows:

5. When the tensile strength determined by the test is less than 63,000 lb., the minimum elongation shall be 25 per cent for plates over ¾ in. and under in thickness and 22 per cent for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is three-fourths the thickness of the specimen. When the tensile strength determined by the test is 63,000 lb. or greater the minimum elongation shall be 22 per cent for plates ¾ in. and under in thickness and 20 per cent for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is one and one-half times the thickness of the specimen. (See 4430 R. S.)

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER SEPTEMBER 10, 1916

MECHANICAL ENGINEERS desirous of securing membership in the Society during the current calendar year must file their applications not later than August 25. Favorable action will then entitle them to attend the Annual Meeting, 1916, as members, receive the 1916 volume of Transactions and be listed in the 1917 Year Book.

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted, by September 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about October 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ARMSTRONG, E. R., Mech. Supt., E. I. du Pont de Nemours & Co., City Point, Va.
BACON, William, Supt. Prentice Dept., Reed-Prentice Co., Worcester, Mass.
BARRETT, George E., Asst. Engr., Sprague Elec. Wks., General Electric Co., Bloomfield, N. J.
BAUMIS, Frank J., with Manning, Maxwell & Moore, New York
BEESON, Alexander C., Chief Engr., Four States Coal Co., Worthington, W. Va.
BEST, William E., Supt., The National Cash Register Co., Dayton, Ohio
BLAKESLEE, Judd W., Supt., Blakeslee Mfg. Co., Du Bois, Ill.
CLINE, McGarvey, Vice-Pres., Florida Pine Co., Jacksonville, Fla.
DANIELSON, John W., Engr., Mgr., Secy., Mecca Machinery Co., Brooklyn, N. Y.
DAVIS, Edwin P., Engr. Exper. Dept., Remington Arms & Ammunition Co., Bridgeport, Conn.
DURR, Herbert A., Cons. Engr. and Mech. Engr., Schmidt, Garden & Martin, Chicago, Ill.
FOSTER, Dean E., Prof. of Mech. Engrg., State College of Washington, Pullman, Wash.
FRENCH, Thomas E., Prof. of Engrg. Drawing, The Ohio State Univ., Columbus, Ohio
GAGE, William P., First Vice-Pres. and Genl. Supt., Lone Star Gas Co., Fort Worth, Tex.
GRANGER, Dean M., Head of Engrg. Dept., Washburn & Granger, New York
HADLOW, H. Ralph, Cons. Mech. Engr., 918 Citizens Bldg., Cleveland, Ohio
HAWLEY, Ransom S., Prof. and Head of Mech. Engrg. Dept., Colorado School of Mines, Golden, Colo.
HICKS, R. L., Mech. Draftsman, Alabama Power Co., Birmingham, Ala.
HOLLANDER, Walter L., Winchester Repeating Arms Co., New Haven, Conn.
KNOWLES, Clarence R., Supt. Water Service, Illinois Central & Yazoo & Mississippi Valley Railroads, Chicago, Ill.
LATHAM, Bernard W., Asst. Mech. Engr., New York Central R. R., New York
LENONE, Jose M., Asst. to Chief Draftsman, Armour & Co., Chicago, Ill.
McKENNA, Alexander F., Supt. of Erection, Western Canada Babcock & Wilcox Co., Montreal, Canada
McPARTLAND, Michael B., Master Mech., Chicago, Rock Island & Pacific R. R., Goodland, Kan.
MOORE, James S., Engr., Greensboro Supply Co., Greensboro, N. C.
MORTON, Arthur B., Chief Draftsman, Messrs. Thompson & Co., Prop. Ltd., Castlemaine, Victoria, Australia
PANGBORN, Thomas W., Pres., Pangborn Corp., Hagerstown, Md.
PESCAY, Charles H., Adjuster, Fire Losses, New Orleans, La.
ROBERTSON, Donald M., Chief Draftsman, The Holt Mfg. Co., Stockton, Cal.
ROWE, Hartley, Elec. Supt., Elec Div., The Panama Canal, Balboa Heights, C. Z.
TROTTER, Henry R., Mech. Engr., S. K. F. Ball Bearing Co., Hartford, Conn
UPTON, George B., Asst. Prof. of Exper. Engrg., Sibley College, Cornell Univ., Ithaca, N. Y.
WALKER, Edwin C., Indus. Engr., The Hess Spring & Axle Co., Cincinnati, Ohio
WOOLSON, Clifford G., Asst. to Chief Engr., Barber Asphalt Paving Co., Maurer, N. J.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BISHOP, Ernest B., Draftsman, Remington Typewriter Wks., Ilion, N. Y.
BJORGE, Oscar B., Chief Engr., Clyde Iron Works, Duluth, Minn.
FELLERS, William M., Chief Draftsman, U. S. Navy Aeronautic Sta., Pensacola, Fla.
HOFFMAN, J. Roy, Vice-Pres., Smith-Booth-Usher Co., Los Angeles, Cal.
HUBBARD, Cecil R., Designing Engr., National Metal Molding Co., Ambridge, Pa.
INGALLS, James A., Mech. Asst., Testing Bureau, Elec. Engrg. Dept., Transit Development Co., Brooklyn, N. Y.
ISHIMURA, Sakichi, Draftsman, U. S. Electro Galvanizing Co., Brooklyn, N. Y.
KING, Howard V., Inspector, with Lima Locomotive Corp., Lima, Ohio
McNINCH, Harry T., Engr., Babcock & Wilcox Co., Bayonne, N. J.
MAYER, Edward R., Supt., City Light & Water Co., Amarillo, Tex.
MEIGS, Robert R., Motive Pwr. Insptr., Pennsylvania R. R., Pittsburgh, Pa.
MILLER, Emilio G., Tech. Staff, Shipyard "Officina Cameller," Para, Brazil
MOREY, Edwin, Secy. and Supt., E. J. Flather Mfg. Co., Nashua, N. H.
ROLLINS, Lewis M., Consulting Engr., 2908 E. Franklin Ave., Minneapolis, Minn.
SILLCOX, Lewis K., Mech. Engr., Illinois Central R. R. System, Chicago, Ill.
SPATZ, Ralph L., Erecting Engr., H. Koppers Co., of Pittsburgh, Pa., Lorain, Ohio
THOMAS, Leon I., Managing Editor "Factory," A. W. Shaw Co., Chicago, Ill.
VERSHBINSKY, David M., Pres., David Vershbinsky, Inc., New York
WENZLIK, Richard H., Architect and Engineer, Houchin-Aiken Co., Inc., Brooklyn, N. Y.

FOR CONSIDERATION AS JUNIOR

ALSFELDER, FERD P., Draftsman, The Lunkenheimer Co., Cincinnati, Ohio
ANTHONY, GRAHAM H., Equipment Supt., William L. Gilbert Clock Co., Winsted, Conn.
BRES, EDWARD W., Inspector, United States Engrg. Dept., New Orleans, La.
CALLAN, JOHN, Engr.-in-charge Roller Plant, Louisiana Irrigation & Mill Co., Crowley, La.
CHALKLEY, CURTIS R., with Cincinnati Planer Co., Cincinnati, Ohio
DEAN, HUBERT R., Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.
DE GROOT, JOHN, Asst. Engr., Westinghouse, Church, Kerr & Co., New York
EARL, RALPH, with George G. Earl, New Orleans, La.
FARNHAM, GEORGE W., Junior Engr., The Elbert Clarke Co., Rochester, N. Y.
HAYES, RALPH S., Student, Dartmouth College, Hanover, N. H.
JACOB, CHARLES L., Engr., Jarrett Chamber Co., Paris, Idaho
JONES, WARREN G., Vice-Pres., W. A. Jones Fdy. & Mch. Co., Chicago, Ill.
KOCH, CHARLES, Ordnance Draftsman, Philadelphia Navy Yard, Philadelphia, Pa.
LIGHTOWLER, GEORGE R., Engr., Austin Baldwin Co., New York
LITHGOW, RICHARD P., Chief Engineer, Arkansaw Water Co., Little Rock, Ark.
LORENTZEN, GUSTAV A., with W. F. Schrafft & Sons Corp., Boston, Mass.
McCARTY, DALE, Mech. Rep., Enterprise Rwy. Equipment Co., Chicago, Ill.
MANUEL, CHARLES J., Mch. Designer and Mech. Engrg., Lewiston Bleachery & Dye Wks., Lewiston, Me.
MUIR, LEONARD S., Ch. Draftsman, with Dwight Seabury, Arch. & Engr., Pawtucket, R. I.
NEWMAN, PAUL A., Asst. Engr., New York Rwys. Co., New York
PARADIES, WALTER F., Mech. Engr., Chile Exploration Co., New York
PRUDEN, RICHARD M., Exper. Engr., Advance Rumely Co., La Porte, Ind.
REED, JAMES K., with S. Keighley Metal Ceiling & Mfg. Co., Follansbee, W. Va.
SCHMITZ, ARTHUR J., Engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
SCHUBERT, FRANK R., Engrg. Dept., Ferro Mch. & Fdy. Co., Cleveland, Ohio
SHEA, THOMAS F., Engr., Canal Construction Co., Memphis, Tenn.
SOLOMON, REUBEN J., Draftsman, The H. P. Townsend Mfg. Co., Hartford, Conn.
STROTT, JOHN C., Asst. Works Engr., Curtis Bay Chemical Co., Curtis Bay, Md.
VANSANT, WILLIAM L., with Dravo-Doyle Co., Pittsburgh, Pa.
WAY, WILLIAM F., 2 First Avenue, Johnstown, N. Y.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

FLOWERS, DEAN W., Supt. Gas Wks. Dept., St. Paul Gas Light Co., St. Paul, Minn.
TILLSON, BENJAMIN F., Head of Mining Dept., The New Jersey Zinc Co., Franklin and Ogdensburg, N. J.
WALDEN, ALBERT E., Supt. and Chief Engr., Baltimore County Water & Elec. Co., Baltimore, Md.

PROMOTION FROM JUNIOR

CAREY, HERBERT W., Chief Draftsman, Harley Co., Springfield, Mass.
NEWCOMB, ROBERT E., Supt., Deane Pump Wks., Worthington Pump & Mchy. Corp., Holyoke, Mass.
STONE, THOMAS W., Mech. Engr., Western Gas Constr. Co., Fort Wayne, Ind.
WINTERROWD, WILLIAM H., Asst. to Chief Mech. Engr., Canadian Pacific Rwy., Montreal, Canada

SUMMARY

New Applications	83
Applications for change of grading:	
Promotion from Associate-Member	3
Promotion from Junior	4
Total	90

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Hicks, R. L.
Arkansas
Little Rock—Lithgow, R. P.
Australia
Castlemaine—Morton, A. B.
Brazil
Para—Miller, E. G.
California
Los Angeles—Hoffman, J. R.
Stockton—Robertson, D. M.
Canada
Montreal—McKenna, A. F.
Winterrowd, W. H. (J.)
New Westminster, B. C.—Peck, J.
Canal Zone
Balboa—Rowe, H.
Colorado
Golden—Hawley, R. S.
Connecticut
Bridgeport—Davis, E. P.
Hartford—Solomon, R. J.
Trotter, H. R.
New Haven—Hollander, W. L.
Winsted—Anthony, G. H.
Florida
Jacksonville—Cline, M.
Pensacola—Fellers, W. M.
Idaho
Paris—Jacob, C. L.
Illinois
Chicago—Durr, H. R.
Jones, W. G.
Knowles, C. R.
Lenone, J. M.
McCarty, D.
Sillcox, L. K.
Thomas, L. I.
Du Boise—Blakeslee, J. W.
Indiana
Fort Wayne—Stone, T. W. (J.)
La Porte—Pruden, R. M.
Kansas
Goodland—McPartland, M. B.
Louisiana
Crowley—Callan, J.
New Orleans—Bres, E. W.
Earl, R.
Pescay, C. H.
Maine
Lewiston—Manuel, C. J.
Maryland
Baltimore—Walden, A. E. (A. M.)
Curtis Bay—Strott, J. C.
Hagerstown—Pangborn, T. W.
Massachusetts
Boston—Lorentzen, G. A.
Holyoke—Newcomb, R. E. (J.)
Lowell—Dean, H. R.
Springfield—Carey, H. W. (J)
Worcester—Bacon, W.
Minnesota
Duluth—Bjorge, O. B.
Minneapolis—Rollins, L. M.
St. Paul—Flowers, D. W.
New Hampshire
Hanover—Hayes, R. S.
Nashua—Morey, E.
New Jersey
Bayonne—McNinch, H. T.
Bloomfield—Barrett, G. E.
Franklin—Tillson, B. F.
Maurer—Woolson, C. G.
New York
Brooklyn—Danielson, J. W.
Ingalls, J. A.
Ishimura, S.
Wenzlik, R. H.
Ilion—Bishop, E. B.
Ithaca—Upton, G. B.
Johnstown—Way, W. F.
New York—Baumis, F. J.
de Groot, J.
Granger, D. M.
Latham, B. W.
Lightowler, G. R.
Newman, P. A.
Paradise, W. F.
Vershbinsky, D. M.
Rochester—Farnham, G. W.
North Carolina
Greensboro—Moore, J. S.
Ohio
Cincinnati—Alsfelder, F. P.
Walker, E. C.
Chalkley, C. R.
Cleveland—Hadlow, H. R.
Schubert, F. R.
Columbus—French, T. E.
Dayton—Best, W. E.
Lima—King, H. V.
Lorain—Spatz, R. L.
Pennsylvania
Ambridge—Hubbard, C. R.
Philadelphia—Koch, C.
Pittsburgh—Meigs, R. R.
Vansant, W. L.
Rhode Island
Pawtucket—Muir, L. S.
Tennessee
Memphis—Shea, T. F.
Texas
Amarillo—Mayer, E. R.
Fort Worth—Gage, W. P.
Virginia
City Point—Armstrong, E. R.
Washington
Pullman—Foster, D. E.
West Virginia
Follansbee—Reed, J. K.
Worthington—Beeson, A. C.
Wisconsin
Milwaukee—Schmitz, A. J.

SOCIETY MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

NEW HAVEN, JUNE 29

The last meeting of the season of the New Haven Section of the Society was held on June 29 at the Mason Laboratory. P. J. G. Reuter gave an interesting talk on the Diesel Motor, which was illustrated with pictures of Swiss machine shops in which Diesel engines are built.

PROVIDENCE, JUNE 28

A meeting of the Providence Engineering Society was held on June 28. Through the invitation of F. E. Winsor, chief engineer of the Providence Water Supply, more than 120 members of the society were taken around the proposed Scituate Reservoir which will eventually supply Providence and some of the neighboring towns and cities with water. The members were accomodated in twenty-five automobiles which were provided by the Water Supply Board.

Following a dinner at the University Club, the annual business meeting of the Society was held. The reports showed that in the past year the membership has doubled. The following officers were elected: Prof. J. Ansel Brooks, Mem. Am.Soc.M.E., *president;* R. W. Adams, G. A. Carpenter, W. T. Robertson, *vice-presidents;* A. E. Thornley, *secretary;* W. C. Kennedy, *recording secretary* and A. H. Whatley, *treasurer.*

Following the business meeting, Mr. Winsor gave an illustrated lecture on the Scituate water supply, detailing the faults of the present system. The speaker said that the source of the Providence water supply at the present time is very polluted, but that the water is reasonably safe because it is filtered. If anything should happen to the filters, however, the people of Providence would have to drink the contaminated water.

G. T. Seabury, an engineer of the Water Supply Board, told of the borings that are being made, particularly at the dam site at Kent, to determine the kind of dam which will be necessary at the outlet end of the reservoir. Borings are being made constantly at this site and at the site for the filters and other places where artificial structures are to be built. He said that they have bored 130 holes from 80 to 92 ft. deep, and have taken samples of the soil every five feet until they struck bed rock. Mr. Seabury also explained the various methods used in drilling and bringing up samples of the soil and the working of the diamond drills used in boring.

F. E. Waterman, another engineer of the Board, told of the problems that were met in determining the ownership of the land condemned by the city. Some of the deeds of the land dated back to 1795 and 1800, and it was very difficult to find an exact or accurate description of the bounds or extent of the parcels of land.

CIVIL ENGINEERS ANNUAL MEETING

The Summer Meeting of The American Society of Civil Engineers was held at Pittsburgh, June 27 to 30.

A notable feature of the meeting was the address of Clemens Herschel on the Advancement of the Profession by the Civil Engineer, which he introduced by a feeling allusion to the death of Dr. Corthell, president of the society, and to whose duties Mr. Herschel succeeds. Dr. Brashear, Past President of The American Society of Mechanical Engineers, addressed the opening session on the attitude of science to engineering.

Of much interest was the announcement of the ballot on the transfer of the society's headquarters from 57th St. to the building of the United Engineering Societies. An overwhelming preference was expressed by vote for the change of headquarters.

ELECTRICAL ENGINEERS ANNUAL MEETING

The thirty-third annual convention of the American Institue of Electrical Engineers was held at Cleveland, June 27 to 30. Professional Sessions were held on Industrial Power, Power Transmission, Protective Apparatus, Electrophysics, and miscellaneous subjects. Percy H. Thomas, Mem.Am.Soc. M.E., chairman of the Institute's Committee on Transmission, presented the report of this committee. J. T. Lawson, Mem. Am.Soc.M.E., was the joint author with N. O. Pollard of a paper on Experience in Recent Developments of Central Station Protective Apparatus.

H. W. Buck was elected president of the Institute for the forthcoming year. Mr. Buck is of the firm of Vielé, Blackwell & Buck, Consulting Engineers in New York, and is also known in connection with the installation of some of the great plants at Niagara Falls.

SOCIETY OF AUTOMOBILE ENGINEERS PROPOSE TO CHANGE NAME AND ENLARGE SCOPE

During the summer meeting of the Society of Automobile Engineers, held on a steamer on Lake Huron, Howard E. Coffin, Mem.Am.Soc.M.E., and a member of the U. S. Naval Consulting Board, and Henry Souther, Mem.Am.Soc.M.E., consulting engineer, Aeronautical Division, War Department, proposed that certain changes be made in the constitution of the S.A.E. so as to include in the field of activities of that society aeronautics, motor boats and tractors. On a motion made by Vice-President E. S. Foljambe, an amendment to the constitution was adopted as follows:

The name of the society to be changed to that of Society of Automotive Engineers, this name having been selected with the view of retaining the former initials.

The society to have affiliated with it automobile, aeroplane, motor boat, tractor and stationary internal combustion engineers.

The new society will have a president, a vice-president and four second vice-presidents, each of the latter in charge of one of the activities of the society.

The work of the new society will be conducted with the coöperation of the Government in the establishment of standards and in the furtherance of the Industrial Preparedness movement.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

These advertisements are placed by members of the Society or persons vouched for by members. The Society is pleased to act as a "clearing house" but is not responsible for results.

In forwarding applications, stamps should be enclosed for transmittal of applications to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society.

DESIGNER; on heavy machine tools and similar machinery; good opportunity for high grade designer with chiefly drawing office experience. Location Pennsylvania. 40.

SALESMAN with technical education as mechanical engineer to become head salesman of company manufacturing heavy capacity automatic scales for factory and warehouse uses; man between 30 and 40; position does not call for an engineer, but business to be transacted is almost entirely with engineers; one-third of time at factory in middle west, two-thirds in field. Salary liberal. 42.

ASSISTANT CHIEF ENGINEER—Young man who has had experience, or special study in the operation of a power plant, to assist in running a wood working factory of 1000 h.p.; knowledge of the design of exhaust steam heating on a large scale a desirable asset. Answer, stating age, past position and salary expected. 83.

DRAFTSMAN experienced in design of heavy machinery, rolling mills, etc. Location, Connecticut. 98.

FOREMAN of shop for manufacturing chemists. Location New Jersey. 104.

CHEMIST for firm of manufacturing chemists. Location, New Jersey. 105.

TEXTILE PLANT ENGINEER; one capable of studying textile operations with view of making improvements in machines or processes; who has had experience in similar lines, or a practical designer in connection with textile machinery. Salary $2,000 to $3,000, dependent upon ability and experience. Location, New England. 130.

DRAFTSMAN; thorough technical training with at least 5 to 6 years practical experience as draftsman and designer of heavy high speed machinery, such as steam turbines, centrifugal pumps and herringbone gears. Must be neat, quick and accurate and possess such characteristics as would justify his promotion to chief or assistant chief engineer in one to two years' time. Salary to begin moderate until ability is proven. Location, Maryland. 164.

DRAFTSMAN; for interchangeable parts on fine balances. Young man with tool making experience preferred. Eastern location. 180.

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Location, Connecticut. 185.

DRAFTSMAN with blast furnace and rolling mill experience. Location, Pennsylvania. 187.

SALES ENGINEERS.—Young men between the ages of 25 and 30 years, of good appearance, graduates of some approved engineering college, preferably M.E. degree; would be expected to undergo a period of probation and training in the various offices of company before being given more responsible and higher positions in sales work. If a call cannot be made, application may be made by letter in the applicant's own handwriting, stating age, education, previous business training, if any, salary desired, etc. Location, New York. 205.

AGENTS to handle sales of products in own territory for firm specializing in manufacture of crushers, adapted for road building, contracting, mining, rock crushing, gravel plants, block and tile plants. 232.

SUPERINTENDENT FOR FACTORY engaged in the manufacture of oil and gasoline engines; must be familiar with modern methods of manufacture, active, tactful, a close student of human nature and a natural leader. Exceptional manufacturing men even though not actively engaged in gas engine work are encouraged to reply. Position offers a splendid opportunity for one who can qualify. Give complete experience. Apply by letter. Name confidential. 246.

MANAGER for firm in India manufacturing clay products, as drainage pipes, tile floors, bricks and wall tiles. Correspondence will be handled through New York firm. 250.

TOOL DESIGNERS and DRAFTSMEN. American or English. Location, near Philadelphia. 255.

ESTIMATOR, experienced in grey-iron and steel castings, pattern and machine work; a position calling first for accuracy. Location Maryland. 273.

TOOL DESIGNERS to take charge of tool drafting department in concern manufacturing small interchangeable parts; one with experience in tool designing for concerns making typewriters, adding machines, electrical apparatus, etc., preferred. In reply state age, nationality, former places of employment, experience and salary expected. 288.

ASSISTANT PROFESSOR IN EXPERIMENTAL ENGINEERING is desired to fill a vacancy in a large engineering school in Atlanta, Georgia, beginning the fall term in September. Applicants must have an engineering degree from some well recognized technical school and either teaching experience or extensive practical experience in experimental and research work. The work involves experimental work, steam, hydraulic and mechanical testing materials, refrigeration and other mechanical subjects. Give full details of education, post-graduate work and practical experience, including references. 293.

MEN EXPERIENCED IN HIGH CLASS GAGE WORK, with practical tool making experience, some organizing power and tact, to visit various plants and pass on gage work for Canadian concern. 320.

ASSISTANT SHOP ENGINEER familiar with wood-working machinery, to look after production side of work and upkeep. Location, Vermont. 327.

GRADUATE MECHANICAL ENGINEER with experience in development and research work, to take charge of experimental department of old established firm manufacturing carburetor equipment for automobile engines. 381. Also one or two assistants. 382.
Scientific soundness and familiarity with systematic methods are of more importance than experience with carburetors, fuels and engines, but both qualifications most desirable. Permanent positions.

YOUNG ENGINEER with experience of one or two years in electrical lines, wiring buildings and plants, motors, etc., for concern in Toronto, Canada. 384.

YOUNG GRADUATE METALLURGICAL ENGINEER for manufacture of steel castings and car wheels, located in middle west, desiring to create position of time study and efficiency engineer for entire plant; prefer graduate of western college. In writing give experience, age, physique, condition of health, denomination, married or single, with whom associated, college and branches of work, salary. 385.

YOUNG ENGINEER, preferably of class 1916, who is willing to start and learn the business from the selling end, of printing press company with headquarters in New York office. 386.

INDUSTRIAL ENGINEER, 22 to 25 years of age, willing to learn the business and make himself useful in the drafting and engineering side of concern of consulting and contracting engineers, sugar factories and equipment, marine work, etc. 387.

MECHANICAL INSTRUCTOR for college in California. Salary $1,000. 388.

MECHANICAL DRAFTSMAN for permanent position with well-known firm near New York City. Several years experience in the design of dynamo electric machinery preferred; must be responsible, accurate and rapid worker, capable of handling detailers and tracers. State age, experience, salary expected and give references. 392.

SEVERAL COLLEGE GRADUATES, of from one to five years experience in manufacturing, wanted by a New Jersey plant, to take positions in production department which is being developed. Salary

to start, $25 a week. Good future for the right man. In making application give full history and record. 395.

ESTIMATOR, young man, technical graduate who has had experience in foundry and pattern work and familiar with cast iron and cast steel, to take charge of estimating department for large foundry. Location Maryland. 397.

TECHNICAL GRADUATE, 1916 preferred, energetic and resourceful for general engineering work in connection with general sales office of concern building fuel economizers and located in New York. 398.

DESIGNER on automatic machinery. Location Brooklyn, N. Y. 400.

SALESMEN ON POWER PLANT EQUIPMENT—Consisting of boilers, engines, force draft blowers, pumps and elevators. Commission basis. 402.

HIGH GRADE ENGINEER, capable of designing and laying out power plants. Location, New York City. 407.

WANTED—by a Company introducing a modern system of management, men who have had both college training and practical experience. Location New Jersey. 408.

EXPERIENCED MAN ON TWIST DRILLS, one thoroughly familiar with twist drill making machines and able to assist in their design for new factory, to have charge of department as soon as started. 413.

SALES MANAGER, fully capable of taking entire charge of sales for old established manufacturing company. Preference will be given to one having experience in steam, plumbing, power plant and water works supplies; a good organizer of salesmen who has demonstrated his ability along these lines. In reply state full details of experience, age and salary expected. A good position with bright possibilities. 414.

DRAFTSMAN, experienced in tool and jig work, salary about $25, opportunity for advancement to right man. Work is on standard line. No war orders. Location Southern Ohio. 415.

SALES ENGINEER, mechanical engineer or salesman with equivalent ability, to sell small special tools direct to the manufacturer. A high grade position for a high grade man. To be considered applicant should give age, references, past experience, salary expected, and whether, or where now employed. 416.

PERMANENT POSITION, with established company developing an epoch making mechanical system, for young graduate engineer with a liking for research work of a practical, semi-commercial nature, preferably with a knowledge of physical chemistry; must be of a practical bent, and willing to begin at the beginning. A good future for a man who knows how to take advantage of an opportunity. Location near New York. 417.

YOUNG ENGINEER familiar with estimating detail and final costs. One familiar with machine shop and metal stamping practice; will afford opportunity for other constructive work in cost department just being organized by large corporation. 418.

HEATING AND VENTILATING DRAFTSMAN; position open in consulting engineer's office for one with sufficient experience and technical training to work out designs for high class installations. Applicants should state full particulars of training, age, experience and salary expected. Location New York City. 419.

INSTRUCTOR in machine shop in a western state college. Must have had shop experience and some technical education. Experience in teaching and ability to interest and instruct young men also essential. 420.

A LARGE PUBLIC INSTITUTION of the Middle Northwest is seeking the services of a strictly high class man who can conduct classes and give lectures on automobiles; must be a technical graduate, have had considerable practical experience and not afraid of work. 421.

DRAFTSMAN for metallurgical plant in process of construction; man should be thoroughly familiar with steel and general construction work. 425.

ENGINEER-SALESMAN capable of approaching with confidence architects and consulting engineers on the larger building operations in New York and vicinity for concern manufacturing steam and water specialties. 426.

TWO ASSISTANT SUPERINTENDENTS, ONE NIGHT SUPERINTENDENT, for concern in Missouri manufacturing special machinery and steel castings. Salary to start $150 to $175 a month according to ability. 428.

INDUSTRIAL ENGINEER, COST ACCOUNTANT.—A well established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special reference to manufacturing costs. In reply state age, education, experience, present and expected salary. 431.

SUPERINTENDENT FOR FOUNDRY employing 250 men, thoroughly experienced on medium and light castings, including gas engine cylinders; must know how to produce good castings with minimum loss and low cost, and possess tact and energy. Give complete details of experience and references and compensation expected. 432.

SALES ENGINEERS OR AGENCY desired for the following territories: Tennessee, North Carolina, Minnesota, North and South Dakota. Past record must show familiarity with boiler plant practice. Work can be handled by engineer, on commission basis, who is handling other lines. 433.

HEATING AND VENTILATING ENGINEER; position involves preparation of specifications, design and supervision of installations of heating and ventilating systems, for State Department of one of the eastern states. 434.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

SUPERINTENDENT OF CONSTRUCTION for the far east. Associate, Japanese graduate of electrical and mechanical school in United States; varied experiences along mechanical and electrical engineering since 1903, now employed with railway company as power house designer, wishes to represent an American engineering company on construction work in Japan or China.—H-266.

ADMINISTRATIVE or EXECUTIVE position. Member technical and commercial training, at present employed, desires to become identified with manufacturing or industrial plant in responsible position. Varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; familiar with the handling of men, drawing up contracts, purchasing equipment and material, modern methods of manufacturing and marketing product—H-267.

LABORATORY and EXPERIMENTAL RESEARCH ENGINEER for mechanical engineering; specialty heat and combustion, calorimetry, fuel economy.—H-268.

DESIGN, CONSTRUCTION or OPERATION of power plants; twenty-five years practical experience in mechanical and electrical engineering. At present employed—H.-269.

MANAGER, ASSISTANT, SUPERINTENDENT, EXECUTIVE or SALES ENGINEER. Associate, age 42, Lehigh University graduate in mechanical engineering; varied experience in mechanical electrical and civil engineering lines involving design, inspection reports, responsible charge of construction work, plant operation, management, purchasing, etc., in connection with power, lighting and industrial plants, electric railways, etc. Salary, $3,000.—H-270.

JUNIOR MEMBER, graduate mechanical engineer, at present employed as assistant to chief engineer, desires position with established engineering firm; desirous of specializing in costs and accounting; will consider salary secondary to opportunity. Available after September 1, 1916.—H-271.

MECHANICAL ENGINEER, Associate member, Stevens graduate, who is energetic, capable of taking initiative and has executive ability, with ten years' engineering experience in power plant work, boilers, stokers, etc., desires position in engineering capacity.—H-272.

MANUFACTURERS' REPRESENTATIVE or SALES ENGINEER; Member; age 37; 16 years' experience in the design of special machinery, compressors, engines, etc.; thorough knowledge of modern factory methods; wide experience in selling organization. Will consider offer as New England representative of a good product that can be developed by efficient and diligent business methods.—H-273.

MECHANICAL ENGINEER, 34, technical graduate, Member, assistant in engineer department; nine years' varied technical and executive experience with a large car building company; divided into designing tools and machinery, plant construction, freight and passenger car designing and estimating; sales engineer and valuation analyst. Desires change to aggressive company, preferably in same line of work and doing an export business.—H-274.

MANAGER, ASSISTANT MANAGER or CHIEF ENGINEER. Age 34. Experienced in the manufacture of water tube boilers and general plate construction as designer, estimator, chief engineer and manager. A good organizer and capable of filling any responsible position in this line of work. Would also consider position as sales engineer.—H-275.

GRADUATE M.E. Twelve years' varied experience. For past six years chief engineer in charge design, construction and maintenance of engineering work, also in charge City light and water department; one and a half years master mechanic of a Colorado sugar factory. One year operating in water and light company; four years' construction experience in turbine department of large company, desires to take up new position of responsibility—September 1st or October 1st. Salary $2,000.—H-276.

SALES ENGINEER, MANAGER or MANUFACTURER'S REPRESENTATIVE. Technical graduate, with present employers since graduation June, 1912, and now department manager. Experienced in sales work in Philadelphia territory; wants to hear from manufacturers of power plant apparatus. Location Philadelphia.—H-277.

SALES ENGINEER, American, age 33, thorough technical training, possesses executive ability, speaks Portuguese, Spanish and German, eleven years' experience in selling electrical and mechanical machinery, excellent references, desires position for Cuba, or as branch manager western part of United States. Thoroughly acquainted with intermountain and Pacific Coast territory.—H-278.

PRODUCTION ENGINEER, FACTORY MANAGER OF TOOLS AND METHODS. Member, wishes to correspond with well established concern. Nineteen years experience in several of the largest and well known concerns in this country and Europe, manufacturing small, and medium size accurate interchangeable parts, such as adding machines, typewriters, cash registers, watches and electrical mechanism. Natural mechanical and executive ability, together with broad experience in developing production of work as mentioned above. Location—Middle West preferred. All correspondence treated as confidential.—H-279.

EXECUTIVE, ENGINEERING or SALES, familiar with sale of oils and handling by pipe lines, motor trucks and ships. Ability to design and install pipe lines, power plant equipment, tanks, etc. Capable of handling accounts and cutting costs. Several years experience in conducting efficiency tests of power plant equipment, lubricants, air compressors and shop material. Technical graduate. Initial salary secondary consideration. Can handle men without friction and obtain results.—H-280.

EXECUTIVE or MECHANICAL ENGINEER, experienced in organization, design of special, elevating and conveying machinery, technical graduate, at present employed, desires interview with parties seeking reliable aggressive man for responsible position. Location New York or vicinity.—H-281.

DRAFTSMAN, technical man with three years shop and two years drafting experience; also one year on production and experimental work seeks position in or near New York City.—H-282.

EXECUTIVE; position desired by member, age 35, American, technical graduate; employed. Thirteen years experience in varied engineering work, mining, smelting, blast furnace and general steel plant work—operation, construction and design.—H-283.

CHIEF ENGINEER, Member, successful designer of automatic machinery, 20 years experience, desires charge of maintenance and operation of industrial plants. At present employed in executive position. Salary $4,000.—H-284.

WORKS ENGINEER, Cornell M.E., 1904, with experience on design of steam and gas engines, in power department of steel mill and on engineering force of large copper smelters, desires position with larger responsibility and a better future.—H-285.

UNIFLOW ENGINES. Mechanical engineer of reputation having long experience with poppet valve engines offers to introduce uniflow enginees (patented) suitable for condensing and non-condensing work. Extremely simple and compact arrangement; several engines in actual operation.—H-286.

MECHANICAL AND STRUCTURAL DESIGNER now doing responsible work for $200 a month, must leave this class of work on account of eye strain. Will start for $100 a month with large firm as traveling salesman. American born; 35 years of age; single; technical education; fifteen years wide experience in engineering work in 10 cities of U. S. and 3 foreign countries. Now in Canada. Pleasing personality and good mixer, especially adapted for dealings with foreigners. Many references.—H-287.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

American Gas Centenary, 1816-1916. *Baltimore, 1916.* Gift of Consolidated Gas, Electric Light and Power Company of Baltimore.

Boston. Metropolitan Water and Sewerage Board. 15th Annual Report, 1915. *Boston, 1916.* Gift of Board.

Cambridge (Mass.) Water Board. Annual Report April 1, 1914-April 1, 1915. *Cambridge, 1915.* Gift of Water Board.

Carnegie Foundation for the Advancement of Teaching. 10th Annual Report. 1915. *New York, 1915.*

——— Bulletin no. 9. *New York, 1916.* Gift of Foundation.

El Sistema de Taylor y su Critica, C. Montullo. *Barcelona, 1916.* Gift of author.

Measuring the Value of Coal. *New York, 1915.* Gift of Fuel Engineering Company.

National Marine Engineers' Beneficial Association. Journal of Proceedings. vol. 14. *Washington, 1916.* Gift of Association.

New York City. Board of Water Supply. Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for the construction of the two gate chamber superstructures, balustrades and brick paving and miscellaneous work at Silver Lake Reservoir, Borough of Richmond. *New York City, 1916.* Contract 144. Gift of Board of Water Supply.

New York State. Department of Health. 35th Annual Report. vols. 1-2. *Albany, 1916.* Gift of Department of Health.

Putting Facts Behind Your Choice of Coals. *New York, 1916.* Gift of Fuel Engineering Company.

The Sanction of International Law. Amos J. Peaslee. Reprinted from American Journal of International Law, April, 1916. Gift of author.

Taxing Incomes of Foreign Investors in American Stocks and Bonds, Amos J. Peaslee. Reprinted from The Columbia Law Review. June, 1916. Gift of author.

Travelers Insurance Company. Year Book, 1916. *Hartford, 1916.* Gift of Company.

EXCHANGES

American Gas Institute. Proceedings. vol. 10, 1915. *New York, 1916.*

——— Membership list, year ending Aug. 31, 1915, corrected to Jan. 1, 1916.

——— Index to Proceedings, vol. 1-10, 1906-1915. *New York, 1916.*

Institution of Engineers and Shipbuilders in Scotland. Transactions. vol. LVIII. *Glasgow, 1915.*

Victorian Institute of Engineers. Proceedings. vol. XIV. *Melbourne, 1914.*

TRADE CATALOGUES

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *June, 1915-May, 1916;* vol. 4, no. 1.

Gould Manufacturing Co. *Seneca Falls, N. Y.* Bulletin no. 120. Multi-stage centrifugal pumps. 1916.

Texas Co. New York, N. Y. Lubrication. *June, 1916.*

Thompson & Co. *Victoria, Australia.* Manufacture of modern machinery in Australia. 51 pp.

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *April-July, 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Abstracts of Current Decisions on Mines and Mining, reported from October to December, 1915. U. S. Bureau of Mines. Bulletin 118. *Washington, 1916.*

Die Abwässer aus der Kaliindustrie. Ergänzungsheft. J. H. Vogel. *Berlin, 1915.*

American Chemical Society. Directory. 1914. Gift of American Chemical Society.

Atlantic Gold District and the North Laramie Mountains, Fremont, Converse, and Albany Counties, Wyoming. U. S. Geological Survey. Bulletin 626. *Washington, 1916.*

Atlas of the State of New York, Julius Bien. *New York, 1895.*

The Authentic History of the United States Steel Corporation, Arundel Cotter. *New York, Moody Magazine & Book Co., 1916.* Gift of publisher.

The author admits a prejudice in favor of the corporation. It is an interesting contribution to industrial history.

By-Products Recovered in the Manufacture of Coke, W. H. Childs. *1916.* Gift of D. D. Berolzheimer.

Bibliography on Valuation of Public Utilities to Dec. 23, 1915. *New York, 1915.* Gift of American Electric Railway Association.

Boston Society of Civil Engineers. Constitution and By-Laws and List of Members, *June, 1916. Boston, 1916.*

Business After the War, G. E. Roberts. *New York, 1916.* Gift of National City Bank.

The Caddo Oil and Gas Field, Louisiana and Texas. U. S. Geological Survey. Bulletin 619. *Washington, 1916.*

Car Builders' Dictionary. ed. 8, 1916. *New York, 1916.*

Carnegie Library of Pittsburgh. Index to the classified catalogue of the Technology Department. ed. 2. *Pittsburgh, 1916.*

Chlorine and Chlorine Products, G. Martin. *London, 1915.*

City Officials of the United States, 1916. Gift of Engineering News.

Commercial Fertilizer. Year Book, 1916. *Atlanta, 1916.*

Cotton Production in the United States. Crop of 1915. *Washington, 1916.*

Concrete Construction for Rural Communities, R. A. Seaton. *New York, 1916.*

Defenseless America, Hudson Maxim. *New York, 1915.* Gift of author.

Deposits of the Useful Minerals and Rocks; Their Origin, Form and Content, F. Beyschlag and others. vol. II. *London, 1916.*

Determination of Time, Longitude, Latitude and Azimuth. ed. 5. U. S. Coast & Geodetic Survey. Special Publication no. 14. *Washington, 1913.*

The Diesel Engine in Practice, J. E. Megson and H. S. Jones. *San Francisco, 1916.*

Dutch East Indies. Jaarboek van het Mijnwezen. 1914—Verhandelingen, Eerste deel. With Atlas. *'s-Gravenhage, 1915.*

Effect of Motion Study Upon the Workers, Frank B. and Lillian M. Gilbreth. Reprinted from The Annals of American Academy of Political and Social Science, May, 1916. Gift of authors.

Electrical Contractor, L. W. Moxey, Jr. *New York, 1916.*

English-French and French-English Dictionary of the Motor Car, Cycle and Boat, Frederick Lucas. *London, 1915.*

The Etheridge Mineral Field. Queensland. Geological Survey. Publication 245. *Brisbane, 1915.*

Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface. *New York, Babcock & Wilcox Co., 1916.* Gift of publisher.

Fauna of the Chapman Sandstone of Maine. U. S. Geological Survey Professional Paper 89. *Washington, 1916.*

Financing an Enterprise, Francis Cooper. A manual of information and suggestion for promoters, investors and business men generally. ed. 4. *New York, 1915.*

Foreign Publications for Advertising American Goods. *Washington, 1913.* Gift of U. S. Department of Commerce.

Die Funkentelegraphie, H. Thurn. ed. 3. *Leipzig, 1915.*

Geology and Coal Resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah. U. S. Geological Survey. Bulletin 628. *Washington, 1916.*

Geology and Mineral Resources of the Southern Coal Field. Part 1—South Coastal Portion. With Maps and Sections. New South Wales. Memoirs of the Geological Survey. Geology no. 7. *Sydney, 1915.*

Geology and Underground Water of Luna County, New Mexico. U. S. Geological Survey. Bulletin 618. *Washington, 1916.*

Ground Water in the Hartford, Stamford, Salisbury, Willimantic and Saybrook Areas, Connecticut. U. S. Geological Survey. Water Supply Paper 374. *Washington, 1916.*

——— in San Joaquin Valley, California. U. S. Geological Survey. Water Supply Paper 398. *Washington, 1916.*

Handbook and Descriptive Catalogue of the Meteorite Collections in the United States National Museum. Bulletin no. 94. *Washington, 1916.*

Handbuch der Gastechnik, E. Schilling and H. Bunte. Vol. VIII. *Munchen, 1916.*

Handbuch der Physikalisch Chemischen Technik für Forscher und Techniker, Kurt Arndt. *Stuttgart, 1915.*

Hydraulics, R. L. Daugherty. *New York, 1916.*

Indiana—Report of a Geological Reconnoissance and Survey 1837 and 1838, D. D. Owen. *Indianapolis, 1839.*

International Engineering Congress. Transactions. Vol. XI—Miscellany. *San Francisco, 1915.*

Die Kaliindustrie und ihre Abwässer, Dr. Tjaden. *Berlin, 1915.*

Kansas. Geological Survey. vol. I. *Topeka, 1896.*

Kon. Instituut van Ingenieurs. Naamlijst der Leden, 1916. *'s' Gravenhage, 1916.*

Lathe Design, Construction and Operation, O. E. Perrigo. *New York, 1916.*

Leading Opinions Both for and Against National Defense, Hudson Maxim. *New York, 1916.* Gift of author.

Locomotive Dictionary. ed. 4, 1916. *New York, 1916.*

Manufacture of Organic Dyestuffs. Translated from the French of André Wahl, F. W. Atack. *London, 1914.*

Die Maschinenlehre der Elektrischen Zugförderung, W. Kummer. *Berlin, 1915.*

Mechanical Engineers' Handbook, L. S. Marks. *New York, 1916.*

Messungen an Elektrischen Maschinen, Rudolf Krause. ed. 3. *Berlin, 1916.*

Microscopical Determination of the Opaque Minerals, Joseph Murdoch. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price, $2.00.

Treats of the technique of mineral examination by treatment with various reagents under the microscope. Ingeniously arranged tables are provided.—W. P. C.

Mineralogic Notes, Series 3. U. S. Geological Survey. Bulletin 610. *Washington, 1916.*

Motor Manual. ed. 15. *London.* Gift of Frank Gilliland.

National Parks Portfolio. *Washington, 1916.* Gift of Department of Interior.

Natural Gas Resources of Parts of North Texas. U. S. Geological Survey. Bulletin 629. *Washington, 1916.*

One Century in Business, 1816-1916. Peter A. Frasse & Co., Inc. History. *New York, 1916.* Gift of Company.

Oscillating Current Circuits, V. Bush. *1916.* Gift of Massachusetts Institute of Technology—Electrical Engineering Dept.

Panama Canal. An engineering treatise. Under the direction of G. W. Goethals. Vols. 1-2. *New York, 1916.*

Petroleum and Natural Gas Prospects at Roma. Queensland. Geological Survey. Publication 247. *Brisbane, 1915.*

Power Transmission by Leather Belting, R. T. Kent. *New York, J. Wiley & Sons, 1916.* Gift of Publisher. Price, $1.25 net.

Belting practice has changed greatly in the past fifteen years. The literature is buried in the transactions of engineering societies and in technical journals. Ths book seeks to gather this into a compilation of the greatest service to the user of belting.—W. P. C.

Predetermination of True Costs and Relatively True Selling Prices, F. A. Parkhurst. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price, $1.25 net.

Outlines a system of scientific records and forms to be used as a basis for determining costs, as used in several well-known manufacturing firms by the author. It is therefore based on actual experience. —W. P. C.

Preliminary Notes on a New Way of Converting Light into Electrical Energy, Theodore W. Case. Read before the New York Electrical Society, June 14, 1916. Gift of Geo. H. Guy.

Public Utilities Reports—Annotated 1916—B. *New York, 1916.*

Public Utilities Digest. Annual 1915. *New York, 1916.*

Schiffs-Dieselmotoren, William Scholz. *Hamburg, 1915.*

Society of Automobile Engineers. Transactions. Part I, 1916. *New York, 1916.*

Spirit Leveling in Louisiana, 1903-1915, inclusive. U. S. Geological Survey. Bulletin 634. *Washington, 1916.*

——— in Maine, 1899-1915. U. S. Geological Survey. Bulletin 633. *Washington, 1916.*

Standard Cloths, Structure and Manufacture, Roberts Beaumont. *London, 1916.*

Statik mit Einschluss der Festigkeitslehre, A. Schau. *Leipzig, 1915.*

Surface Water Supply of the United States, 1914, Part III. Ohio River Basin. U. S. Geological Survey. Water Supply Paper 383. *Washington, 1916.*

Tennessee—Sixth geological report to the 24th general assembly, Nashville, 1841.

The Three Position Plan of Promotion, Frank B. and Lillian M. Gilbreth. Reprinted from The Annals of the American Academy of Political and Social Science, May, 1916. Gift of authors.

Tonométrie, F. M. Raoult, *1900.*

Transportation Rates and Their Regulation, H. G. Brown. *New York, 1916.*

Tungsten and Molybdenum. Part I-II. Tasmania. Geological Survey Mineral Resources, no. 1. *Tasmania, 1916.*

U. S. Bureau of Census. United States Life Tables, 1910. *Washington, 1916.*

U. S. Patents on Wood Preservation, Jan. 1, 1880-Mar. 31, 1916. D. D. Berolzheimer. Gift of author.

Untersuchung des Wassers an Ort und Stelle, Hartwig Klut. ed. 3. *Berlin, 1916.*

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Economy in power generation has always been a leading topic among engineers, but never so vital as now, when the approaching competition among nations is more and more emphasizing the necessity of attaining the highest efficiency in all departments of industrial life of a nation. In one field of industry in particular there are additional reasons for endeavoring to reduce the cost of power as much as possible, and that is in the central station field. There the necessity of meeting the growing cost of labor and raw materials without raising rates in a corresponding manner on one hand, and the constant supervision of and accountability to various public utility boards on the other, makes it particularly essential to keep down the unit cost of power as low as possible.

This can be achieved in one of two ways, dependent upon local conditions. The central station with very large loads can meet the difficulty by increasing tremendously the size of the unit, and in the present issue a brief description is given of some of the features of one of the largest power generating units in the world, Unit No. 3 at the Northwestern Station of the Commonwealth Edison Company of Chicago, rated at 45,000 h.p.

For small stations with widely varying loads, one way of reducing power cost is to introduce types of prime movers equally or nearly equally efficient at loads varying from about one-third to peak. The double-nozzle gear-type steam turbine described in the section Steam Engineering offers one of the solutions of the problem.

THIS MONTH'S ARTICLES

An abstract of an article describing the fuel oil installation and equipment on the Florida East Coast Railway gives, among other things, a comparative statement of fuel cost per engine mile with coal and oil.

In the section Foundry will be found a report of some practical results that have been obtained by the use of steel scrap in the different classes of castings produced in the foundry of a company making carwheels.

The casting of non-ferrous metals in chill molds is described, and a table is given showing the comparison of the physical properties of copper alloys cast in sand and permanent molds.

Two articles are abstracted on the flow of viscous fluids, one on flow of oil through orifices and the other on the carrying capacity of pipes for viscous fluids. In the first of these articles an interesting fact is disclosed, namely, that the discharge for a given orifice is always the same with a given pressure, provided the oil be at or above its critical temperature.

An abstract of an article on roll pressures in cold-rolling steel gives formulæ for the pressure used as a function of the projected area of the rolls in contact with the metal.

Oliver W. Storey presents a discussion of the sherardizing process, in which an attempt is made first to establish conditions insuring the uniformity of the product, and second to show how a maximum protection of iron may be obtained with a minimum expenditure of zinc dust. Among other things the writer shows that it is of great importance to maintain a uniform metallic content in the zinc dust, and also explains the fact, which seemed to be quite puzzling, that concerns which obtained very good results with sherardizing at first began to have trouble after having used the process for some time. It seems now that the cause of this was simply the enrichment of the dust by iron, which made it necessary to use a high temperature for sherardization, resulting in a coating less resistant to weathering.

A method of hobbing high prime-number spur gears is described by Will. O. Wynne. Curiously enough, the machine described, which permits of hobbing a gear with any number of teeth up to 1000, is actually simpler than the ordinary machine, which cannot hob high prime numbers.

C. D. Young, Mem. Am.Soc.M.E., shows by a number of tests that, providing proper care is taken in the handling of steel during the quenching process, water is preferable to oil as a quenching medium. He also recommends that in all specifications for forgings which are to be heat treated there be included a clause to govern the allowable amount of segregation.

In the section Mechanics, attention is called to the article on the whirling speed of shafts by W. M. Wallace.

Firing and Fuel

Fuel Oil Installation and Equipment

Description of the fuel oil installation and equipment on the Florida East Coast Railway, the most recent of the large systems to change from coal to oil fuel for its locomotives. This change was made only after considerable preliminary experience involving the conversion of some twenty-five engines from coal to oil burners.

The locomotive equipment used is characteristic of that employed on other large systems. A Clarke burner is used; the installation is fully described in the article. The fire pans are of the round bottom variety sloping from back to front in such a way that whatever surplus of oil may accumulate in the pan is drained out at the forward end and does not bring about danger from explosion. A course of brick is set on edge along the sides of the fire pan to protect the lower portions of the side sheets from the intense heat, and at the same time assist in sealing the pan at the point of its attachment to the mud ring.

Particular attention has been given to the matter of draft. Air is admitted at two points, through a damper at the front wall of the fire pan and through a second damper controlling the supply through the flash hole located about two-thirds of the distance from the burner back to the rear of the pan.

The perforations in the front wall of the fire pan covered by the first mentioned damper have inserted in each a 4-in. length of tubing. Air supply for combustion is received at this point during the operation of firing-up. After steam has been raised and the engine starts working this damper may be partly or entirely closed, and, further, air for combustion may be received through the second damper at the flash hole. This second damper is manipulated by means of a notched lever set in the floor of the cab.

Table 1 gives a comparison of the fuel expense per engine mile as between coal and oil for a period ending with the month of March, 1916, from which it is seen that a saving of about 18 per cent in the cost of fuel has been realized from the use of oil. (*Railway Review*, vol. 58, no. 26, p. 903, 4 pp., 6 figs. *a*.)

TABLE 1. COMPARATIVE STATEMENT OF FUEL COST PER ENGINE MILE, COAL vs OIL, FLORIDA EAST COAST RY.

		Cons. of	Avg. Price.			
Coal—	Mileage.	Coal-tons.	Per ton.	Cost.	Miles run per ton.	Cost per mile run.
Forwarded.	1,304,663	71,524	$3.03	$216,722.97	18.24	$0.166114
March.....	237,920	13,667	3.07	41,957.69	17.41	.176352
Total & avg.	1,542,583	85,191	$3.04	$258,680.66	18.11	$0.167628
Oil—		Gal.	Gal.		Gal.	
Forwarded.	467,341	3,719,841	$0.017	$63,482.97	.126	$0.135830
March.....	115,591	991,367	.0168	16,654.97	.117	.144085
Total & avg.	582,962	4,711,208	$0.017	$80,137.94	.124	$0.137467

Foundry

Steel Scrap in Various Foundry Mixtures, G. S. Evans

Report of some practical results that have been obtained by the use of steel scrap in the different classes of castings produced in the foundry of the Lenoir Car Works of Lenoir City, Tenn., of which the writer is superintendent.

At first this Company used, in the manufacturing of car wheels, a mixture consisting of different grades of charcoal pig iron and scrap wheels, the mixture being made by fractural grading. A large percentage of the wheels had been rejected by the railroad inspector on account of either drop or thermal failures. A small percentage of scrap steel was then added in place of a portion of the No. 6 and 7 grades of charcoal pig iron, the mixture being figured on the analysis basis instead of by fracture. An improvement was noticed. By degrees the addition of steel was increased from 10 to 12 per cent. Now 10 per cent of scrap steel is regularly carried in the mixtures for general locomotive and car castings, the other components being 30 to 40 per cent pig iron and 50 to 60 per cent machinery and returned scrap. The writer found that in this mixture the use of steel closes the grain of the casting and increases the strength without affecting the chilling qualities sufficient to cause any trouble even in very thin sections. While the use of scrap steel in these amounts tends toward improving the quality of the casting, it does not, in the belief of the writer, give any distinctive characteristics to the metal that would warrant any claim for it other than that of being a good grade of machinery or chilled casting. With larger percentages of steel, and when properly melted, however, an iron is produced which apparently could not be obtained without the use of steel. Under ordinary foundry conditions such castings are more expensive to produce, are more efficient for certain specific uses, and consequently demand a higher price regardless of the name. In special light castings, which include light pipe fittings requiring high strength and great density, 30 to 40 per cent of scrap steel is used. An interesting discussion is presented on carwheel chillers. Until some three years ago when the writer began experimenting with special chiller mixtures he was of the opinion that the softer the chiller, the more adapted it would be to the service conditions, those of periodical expansion and contraction. Practical tests have shown, however, that the resistance of the metal to sudden expansion and contraction depends essentially neither on hardness nor the chemical constitution of the metal but upon its metallurgical structure.

Tests were made to determine the effects of the addition of steel on the strength and properties of test bars cast from irons of like analysis. It was found that the semi-steel iron shows an increase of 61.4 per cent in tensile and 23.9 per cent in transverse strength over the gray iron; the hardness as shown by the Brinell test is slightly greater in the case of the semi-steel but the "toolability" of both is approximately the same. The useful characteristics of semi-steel are its uniformity of structure throughout the whole section of a casting and freedom from paper chills; but correct cupola practice is very essential to the successful production of semi-steel. While there is no specific formula by which to melt it, as a general rule it is essential to use smaller cupola charges and greater total tuyere area than commonly. The writer found a charge of 150 lb. of metal per sq. ft. of cupola area and a tuyere ratio of 1 to 5 to give very satisfactory results in cupolas from 32 to 84 in. in size. (*The Iron Age*, vol. 97, no. 26, p. 1541, June 29, 1916, 5 pp., 27 figs. *dp*.)

The Casting of Non-Ferrous Metals in Chill Moulds, F. Johnson

After a brief discussion of the advantages obtainable with chill molds the author proceeds to the consideration of the molds themselves. Of the three materials suitable for these molds, gray cast iron and steel have been used and found satisfactory (the third is malleable cast iron). Cast-iron molds should be produced with a generous allowance for machining to the exact dimensions required for the production of a casting, and also for the removal of surface defects. The thickness of the walls of the mold depends upon its size.

For small castings the walls need not be more than 2 in. thick. Steel molds may be thinner.

Whether the parts of the mold form vertical or horizontal joints, strong clamps, of a simple type adapted to rapid tightening and loosening, should be provided. If the parts of the mold are hinged together, the hinges should work smoothly and easily. Strict attention should be paid to the venting of the joints, since if there is insufficient provision for the escape of air the casting will either be spongy or its surface spoiled by the presence of air pockets.

The composition of the iron for cast-iron molds is important. The iron should be tough and close-grained and free from blowholes. W. J. May recommends the following composition of iron sucessfully used for molds:

	Per cent
Combined Carbon	0.84
Graphitic Carbon	2.76
Silicon	2.02
Sulphur	0.07
Phosphorus	0.89
Manganese	0.29

The high phosphorus content is justified by May on the ground that the fluidity which it confers enables molds of sharper outlines to be produced. He also states, however, that an iron high in combined carbon would probably grow and become deformed under repeated heating. The presence of phosphorus, moreover, increases brittleness, and therefore a cast iron with a low phosphorus content is preferable, for even if sharp outlines are not obtained the surface can be machined.

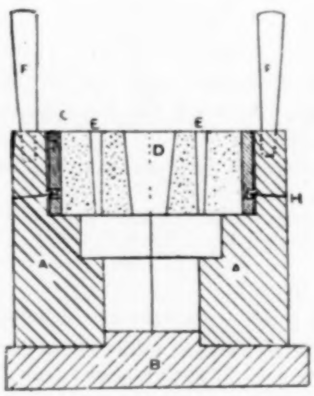


FIG. 1 CROSS-SECTION OF PERMANENT IRON MOLD FOR NON-FERROUS METALS

To protect the mold surface and to facilitate the extraction of the casting, a coating is applied. Seal oil liberally mixed with fine plumbago appears to be as satisfactory as anything. In contact with the molten metal partial distillation of the dressing takes place, with the production of gaseous hydrocarbons which are trapped in the casting before they can gain egress from the mold. Just sufficient coating is required to form a gaseous envelope between the casting and the mold to give a clean surface to the former, to facilitate its extraction and to protect the surface of the mold. If carbonaceous coatings are considered undesirable, an emulsion of bone ash and water applied with a brush to the warm surface of the mold should prove satisfactory.

Steel cores appear to be preferable to sand cores in iron molds. The provision of a satisfactory gate for chill molds has introduced difficulties. Owing to the rapid chilling effect of the iron no marked constriction of space at the junction of the head with the casting can be allowed, as the setting of the metal is likely to take place here before the casting has solidified. By carefully diminishing the rate of pouring as the mold fills, this difficulty may be partly overcome; but still a considerable amount of metal is required for the head when formed in the mold itself. The writer tried to use a much smaller head, kept molten until after the solidification of the casting. To do this the gate was made in sand in a detachable ring placed on top of the mold, and kept firmly in position while pouring. The lower thermal conductivity of the sand enabled the small head to do all the feeding. A small riser was also added for the purpose of securing free egress of gas and air from the mold. In Fig. 1 the halves of the mold are indicated by A; B is the cast iron base and C the steel ring for sand. The gate is shown at D; E E are the risers and F F the handles. The small heads proved that the feeding was satisfactory. In one experiment the weight of the head represented only 8 per cent of the total weight of metal used. This method also has the advantage of securing a more effective elimination of dross, air and gas.

TABLE 2. COMPARISON OF THE PHYSICAL PROPERTIES OF ALLOYS CAST IN SAND AND PERMANENT MOLDS.

Composition	How cast	Yield point, tons per sq. in.	Breaking stress, tons per sq. in.	Elongation per cent	Reference
Copper, 85 per cent.; aluminum, 5 per cent...	Sand	4.3	18.1	75.0	Eighth report of the alloys research committee, 1907
Copper, 85 per cent.; aluminum, 5 per cent...	Chill	7.1	18.1	60.5	
Copper, 90 per cent.; aluminum, 10 per cent..	Sand	11.3	31.7	21.7	
Copper, 90 per cent.; aluminum, 10 per cent..	Chill	12.4	36.93	30.5	
Copper, 88 per cent.; aluminum, 10 per cent.; manganese, 2 per cent..	Sand	13.2	34.44	24.0	Ninth report of the alloys research committee, 1910
Copper, 88 per cent.; aluminum, 10 per cent.; manganese, 2 per cent..	Chill	16.8	37.0	25.0	
Copper, 56 per cent.; zinc, 41 per cent.; iron, 1.5 per cent.; tin, 0.9 per cent.; aluminum, 0.45 per cent., and manganese, 0.15 per cent.....	Sand	...	33.44	20.0	
The same alloy as given above.................	Chill	...	38.4	25.0	

In producing brass castings in chill molds, the elimination of dross from the surfaces of the casting has proved to be the greatest difficulty. The position of the mold has some bearing on the problem. The best way to secure castings with smooth cleaning surfaces is to prevent ingress of all dross and oxide to the mold. A suitable flux which will dissolve zinc oxide is useful. The addition of aluminum to copper-zinc alloys has the effect of checking oxidation of the zinc, and no other deoxidizer has been proved to have such a marked influence in this respect.

To prove that dross was the cause of rough surfaces, the following experiment was made: A graphite crucible was

pierced at the bottom with a 1/4-in. hole, and a 1/2-in. arc-lamp carbon was used to plug up the hole and act as a stopper. This crucible was heated to redness and placed in position over the gate of the mold. Molten metal was poured into the hot crucible, and when it was reasonably certain that all the dross had risen to the surface the stopper was removed and the clean metal from the bottom was allowed to teem into the mold. By this means castings were produced quite free from surface imperfections.

The superiority of the mechanical properties of chill castings over sand castings may be seen from the data collected in Table 2. (Paper read before the Birmingham, England, Branch of the British Foundrymen's Association, abstracted through *The Mechanical Engineer,* vol. 37, no. 958, p. 429, June 2, 1916, 3 pp., 3 figs. *pd.*)

Hydraulics

Flow of Oil Through Orifices

Data of measurements of flow with fuel oil, power distillate,

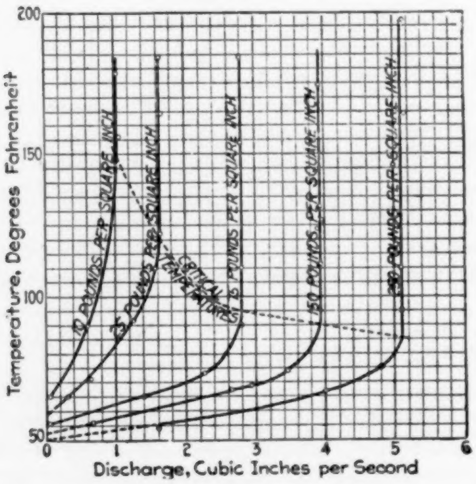


Fig. 2 Discharge of Steam Cylinder Oil at Different Temperatures

and Kansas crude under different pressures and with different sized orifices, made last year at the State University of Iowa. The experiments were made at a constant temperature of 70 deg. fahr., with six pressures ranging from 10 to 350 lb. and five orifices ranging from 0.0232 to 0.0807 in. diameter. Additional tests in which the temperature was varied were made on heavy steam-engine cylinder oil.

The most interesting results were obtained with the steam cylinder oil. Observations were made in which the temperature was varied from 50 to 200 deg. fahr, using the 0.063 in. orifice and pressures from 10 to 250 lb. It was found that at each pressure there was a temperature above which the discharge became independent of the temperature and below which the discharge dropped off at an increasing rate with a decrease in temperature. These critical temperatures decrease as the pressure increases. Fig. 2 shows the relation between discharge and temperature of this heavy oil.

The discharge per second above the critical temperature is in all cases nearly the same as the discharge for the other oils at 70 deg. fahr. This would point to the fact that, no matter what kind of oil be used, the discharge from a given orifice with a given pressure will be always the same if the oil be at or above its critical temperature. (From thesis by G. P. Anthes, *Power,* vol. 44, no. 2, p. 58, July 11, 1916, 2 pp., 5 figs. *e.*)

The Flow of Viscous Fluids Through Pipes, W. K. Lewis

Investigation of the carrying capacity of pipes for liquids other than water, of interest because of the lack of any published figures on this subject.

Previous investigations have shown that at low velocities viscous liquids move in straight lines parallel to the axis of the tube, but when the velocity is sufficiently increased the lines of flow become distorted, the filament forming violent eddies of constantly changing form and position. From this the author deduces that at least two different laws must govern the flow of fluids, the one above and the other below the critical velocity, with the possibility of a third for an intermediate state. Poiseuille's law would be the one to use below the critical point, since his formula applies entirely to straight line motion. For flow above the critical point, the author suggests an equation derived from observation of the formulæ for flow of steam, air and water above the critical point. This formula is

$$P = \frac{f \varsigma l V^n}{gr}$$

(notation at end of abstract) and it is surprising to find that they all have approximately the same constant f and also nearly the same value of n.

For the expression of pressure drop, the author suggests a general equation

$$P = \frac{(K\chi + C)V^n}{d^m}$$

for all sizes of pipes with varying velocities and different degrees of internal roughness (the constants doubtless vary). The author shows that flowing liquids of all viscosities, when in sinuous motion, follow substantially the same equation, differing only in the coefficient of that equation; that is, the flow of any liquid in sinuous motion may be expressed as a constant times some function of velocity length and radius, this function being independent of the viscosity.

For estimating the carrying capacity of the pipe for viscous liquids, the author suggests the formula

$$f = f_w \ (0.955 + 0.045 \ z)$$

where f_w is the hydraulic coefficient for the flow of water through a pipe, f that of any liquid, and z is the relative viscosity of the liquid in question to water. The best way to determine z is to measure the relative time of efflux of the liquid and water through the same capillary tube. The writer experimentally confirms the accuracy of this formula by data up to viscosities of twenty-fold that of water. Up to this point the equation term for viscosities in the different formulæ is small, but for very high viscosities such as are encountered in heavy mineral oils, glycerin, etc., this term becomes very great. In fact the writer doubts the validity of this formula for high viscosities.

Liquids of even moderate viscosity flowing under low heads follow viscous motion unless the pipes be very large. As long as the motion is viscous, doubling the size of the pipe increases the velocity four-fold and the discharge sixteen-fold for the same pressure drop.

Liquids flowing through pipes flow either in straight-line

motion, in which case they follow Poiseuille's formula,

$$P = \frac{8\mu l V}{g r^2}$$

or in sinuous motion, the pressure drop being represented by

$$P = \frac{f l \rho V^2}{g r}$$

The flow will follow that formula which requires the higher pressure drop, the higher radius, or gives the lower velocity, as the case may be. Both formulæ must therefore be employed, and the result chosen according to the above rule. To obtain the coefficient f of the formula for sinuous motion: look up, in suitable hydraulic tables, the value of the coefficient for water flowing in the same size pipe at the same velocity, and multiply this coefficient by the expression $(0.955 + 0.0452z)$ wherein z is the viscosity relative to water of the liquid flowing.

These formulæ have been experimentally substantiated only for use in pipes up to 2 in. in diameter and for the flow of liquids of viscosity (relative to water at 20 deg.) of 20. They are probably safe for use in larger pipes and at higher viscosities, but more exact expressions for these conditions must be determined by further experimentation.

Nomenclature

P = pressure drop in grams/cm². or lb./sq. ft.
μ = coefficient of absolute viscosity in sec. dynes/cm². or sec. poundals/sq. ft.
l = length of the pipe in cm. or ft.
r = radius of pipe in cm. or ft. (d = diameter)
ρ = density of the fluid
V = mean velocity in cm./sec. or ft./sec.
f = hydraulic frictional coefficient.

(*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 7, p. 627, July, 1916, 6 pp., 4 figs. *eA*.)

Machine Shop

THE PAINTING OF IRON AND STEEL, James Scott

The paper is based on the fact discovered on the Continent (The Journal, 1912, p. 637) that a single coat of paint resists the rust of the metal more than either two, three or four coats. From this the writer comes to the conclusion that it may be possible to not only economize in paint but to obtain better results by this less expensive method.

Although paints do not appear to possess much structure when viewed by the naked eye, the pigments of which they consist are revealed very definitely upon magnification. In some cases the granules are exceptionally minute, uniform and equally distributed. Frequently, however, they are either initially coarse, or coalesce into groups which practically become enlarged nodules. In many specimens the actual speck-like pigment is accompanied by semi-crystalline particles of apparently large dimensions either hard or soft, or a mixture of the two kinds, and upon these objects depends to a great extent the success or failure of the paint to be properly protective. The nature of the solvent is also important and operates with much influence in regard to the pigment itself.

The writer covered glass slides thinly with even coats of various paints, and then sent reflected light up through them on the assumption that what is seen on the glass is the same formation as when it is over the metal, unless indeed the irregularities are increased, thus helping to understand what happens. The author gives several plates depicting films of various kinds. The one reproduced here in Fig. 3 is a view of a black varnish paint containing a fair proportion of spirit "turps," the presence of which produces a very different modification explained subsequently.

A wholly spirituous paint or varnish resolves itself into a gyrating mass of comparatively large globules owing to the extreme mobility of the solvent. The granules are rolled over most remarkably, and arranged alternately into a central spot in each globule, and swished to the contours where they meet others adjoining and form large angular patterns. These movements keep up until the solvent has evaporated, and then the granules subside and coalesce into overlying flaky films. The point to note is that as the globular collections of pigment granules are disposed of they produce bold hexagonal designs with intervening clear spaces. Air and moisture can find their way underneath the flakes, and when the latter harden there remain little tunnels level with the plane of the metal.

The outer surface of paint dries first so that the resultant film thus formed tends to press down upon the softer under part and force it into available cavities, thereby filling them with pigment and rendering them fairly impervious.

In actual practice the following happens: A moderately

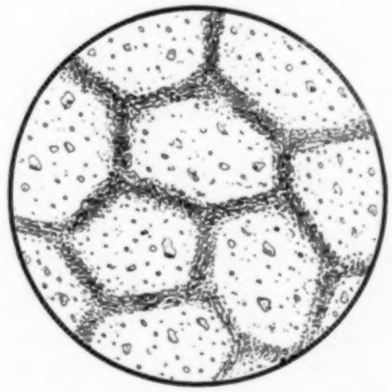


FIG. 3 A PORTION OF BLACK QUICK-DRYING OR SPIRITUOUS PAINT, ABOUT 1/24 IN. WIDE. COMPARATIVELY LARGE MOBILE GLOBULES SHIFT THE PIGMENT GRANULES INTO VARIOUS PATTERNS, BENEATH WHICH SLENDER TUNNELS FORM

thin layer of paint is applied. It dries with open spaces around its larger granules; then there are tiny cellular cavities where free oil globules or air have been present, narrow under grooves, and scattered particles of fairly large size. To all appearances it becomes hard, firm and intact, but really it is not so. Upon adding another coat to this first one, it is partly redissolved; the fresh substance soaks rapidly through the spaces of the first layer and resoftens the under parts. It also dissolves the soluble granules and thus opens up for itself an extra number of passages. The second coat apparently dries, but in reality it has made an increased amount of porosity. Each additional coat must be supposed to produce the same effect until finally when we think there is a thick, firm water-proof layer, it is really slenderly honeycombed from top to bottom with intercommunicating pores as invisible as those in an egg shell, and yet as free as the latter in admitting air and vapor. On the other hand, if a fairly thick single coat of paint is laid and undisturbed by too much brushing, the fine pigment granules and the larger particles sink to the bottom and the solvent flows above them and during gradual oxidation prevents the formation of the empty spaces. (*The Railway Engineer*, vol. 37, no. 437, p. 133, June 1916, 2 pp., 3 figs. *edp*).

Third Annual Convention of Drop Forgers

Brief abstracts of papers presented at the third annual convention of the American Drop Forgers' Association held in Philadelphia, Pa., June 9 and 10, 1916.

Of these addresses the following are of general interest to mechanical engineers: R. T. Herdegen read a paper on the selection of proper machines for making forgings, in which he pointed out the necessity of the selection of machine units suited to the particular job in question as a means of securing minimum costs. He considered three types of machines, board drops, steam drops and upsetting machines, and gave examples to show a minimum cost job for each type with figures including die cost, material, direct labor and the complete overhead charges.

Jules Dierckx in a paper on multiple mechanical die sinking pointed out the advantages of mechanical sinking of dies on the Keller machine.

J. F. Zwicker gave an interesting and detailed description of his method of producing the Elliott type I-beam section

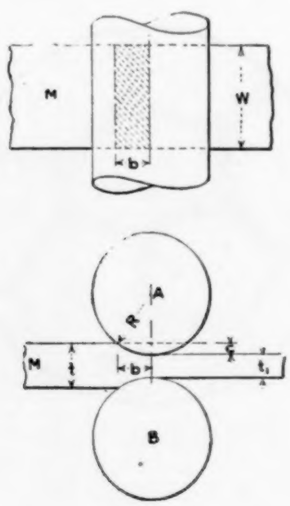


Fig. 4 Diagram of Rolls Acting on Metal

front axle for automobiles, as used in the Overland car. The discussion of this paper brought out the feasibility of thin forging alloy steel flanges; according to Mr. Zwicker's experience this is possible on a 7½ in. diameter flange 5-16 in. thick, gathered from 1½ in. stock, this case being the wheel flange on the rear axle.

W. C. Peterson presented a series of personal investigations on different methods of heat treatment of drop forgings, with particular reference to automobile forgings. He told of tests on the structure of the same forgings made under a varying number of blows and pointed out the advantage in granular structure and tensile strength secured by a large number of blows.

H. N. Taylor's paper on the manufacture of drop forging steel dealt with the method of rolling billets into bars, with a view to eliminating pipes and seams, as applied to carbon-steel forging stock produced by his company.

W. C. Lytle, in his paper on sand blasting of forgings, described the methods of cleaning forgings by pickling, tumbling and various types of sand apparatus, including the barrel type, the cabinet type, hose type and table type. During the discussion the purposes of sand blast for uncovering defects was taken up. The difficulty in cleaning alloy steel forgings by the sand blast process were said to be overcome by the use of No. 5 round chilled-steel shot. A member told of the installation of wire brushes at his hammers at the Buick plant for the purpose of uncovering defects prior to completing the forgings.

A. A. Holbeck (Sources of Heat for Forging Furnaces) described the operation of a powdered coal plant adapted for small furnaces, with distribution of coal by air in galvanized pipes. As small a fuel consumption as 10 lb. per hour per furnace is possible with this system; the temperature of combustion is 3400 deg. and the final cost with coal at $3.00 per ton is equivalent to fuel oil at 1½ cents per gallon.

F. O. Andrews illustrated the recent developments in the use of upsetters by showing a forged spiral beveled gear blank in which the teeth had been produced in a total of three operations on an upsetter.

During the executive session a resolution was passed unanimously placing the members of the American Drop Forgers' Association on record as holding themselves in constant readiness at all times to serve this country with their trade, knowledge and equipment for any necessary military defensive action the Government may require from them. (*American Machinist,* vol. 44, no. 25, p. 1082, June 22, 1916, 2 pp., *g.*)

Roll Pressures in Cold-Rolling Steel, Wm. K. Shepard and George C. Gumer, Mem.Am.Soc.M.E.

Report of an investigation carried out in the Mason Laboratory of Mechanical Engineering at the Sheffield Scientific School of Yale University into the pressures required to cold-roll annealed hot-rolled steel and unannealed steel that had been partly cold-rolled.

One grade of steel was used in all of the tests,—0.10 per cent. carbon and under.

The article describes the methods of conducting the tests and presents the results in the form of tables and curves, the latter being plotted with the pitch in inches as abscissae, and pounds pressure for a strip one inch wide as ordinates. The curves either have a slight curvature, usually in the early part, or practically follow the straight line law. When rolls of different diameters are used, the pressure will, it is believed, depend on the projected areas of the rolls in contact with the metal (the meaning of this term is shown in Fig. 4).

When a piece of metal 1 in. wide is being rolled between the rolls A and B from a thickness t to t_1 in., the projected area of the rolls acting on the metal will be equal to b, the sectioned area in the top view. For a strip of metal w in. wide the projected area will be w times that for a 1 in. width. The per cent rolling will equal $(t - t_1)/t$. From Fig. 4 it is seen that the projected area b for any pinch $t - t_1$ on a 1 in. strip can be found from the relation

$$b = \sqrt{R^2 - (R - C)^2}$$

where R = radius of the rolls and $C = (t - t_1) \div 2$. The writer has calculated the values of the projected areas of various rolls from 5 to 20 in. acting on a strip of metal 1 in. wide for different amounts of pinch. When the values so obtained are plotted on logarithmic cross-section paper, it is seen that there is a straight-line relation between the projected areas and the different pinches of each size of rolls. The ratios of these projected areas of different size rolls to the projected areas of 5-in. rolls for three pinches, are given in a separate table. (*American Machinist,* vol. 44, no. 26, p. 1117, June 29, 1916, 4 pp., 6 figs. *e.*)

The Sherardizing Process, Oliver W. Storey

Discussion of the sherardizing process, mainly from the point of view of securing the maximum of protection of iron with the minimum expenditure of zinc dust. This question has become now of particular importance because of the spectacular rise in the price of zinc.

The exact compositions of the alloys of zinc and iron are not known. The solubility relations of the two metals have been studied by Wologdine and von Vegesack, but their results are not entirely in accordance. This makes the exact nature of the alloys formed in sherardizing of some doubt. Several investigators have made a study of the zinc-iron alloys formed in the sherardizing process but came to different conclusions. They have found the iron content to vary from 9 to 30 per cent, and the coating to consist of from one to four layers of different zinc-iron alloys.

The writer has determined to a limited extent the effect of temperature on the iron content of sherardized coatings. The analyses were made on coatings of approximately the same thickness with the same time of deposition, while the concentration of zinc in the dust determined the temperature necessary to secure a given thickness of coating. Unfortunately it was impossible to secure accurate temperature measurements.

The metallic content of the zinc dust varied from 18 to 42 per cent. The variation in temperature necessary for these extremes was about 65 deg. cent., the higher metallic content requiring the lower temperature. The data obtained with intermediate metallic percentages showed that the iron content of the sherardized coating is proportional to the temperature used, the rate of deposition being constant. This explains the variation in iron percentages reported by earlier investigators, as no investigation of the sherardized coating with reference to its structure can be considered complete without a knowledge of deposit conditions. The higher the temperature of deposition the higher the percentage of iron in the alloy, providing the rate of deposition is the same.

The author discusses also the sherardizing of copper, and thinks that copper and zinc form two definite compounds at sherardizing temperatures, CuZn and $CuZn_2$, while no others are formed. Further, from the results obtained in sherardizing copper he concludes that the higher temperature results in a higher copper content in the coating and the alloys formed are in definite layers, each having a definite composition corresponding to an intermetallic compound.

From this the author proceeds to a discussion of the theory of sherardizing. He finds that the so-called vapor theory is not without objections. He found much trouble in the sherardizing of large pieces of flat work in non-revolving boxes; if the dust was not in close contact with the entire area those parts which were not touched by the dust were not sherardized. The sherardizing process should not become confused with the vapor coating process, in which much higher temperatures are used.

The writer compares the behavior of zinc with that of other metals, and finds that sherardizing may be carried out with various metals, especially antimony, at temperatures used ordinarily in sherardizing with zinc dust. He further points out that zinc at the sherardizing temperature is more or less plastic and can be easily welded or joined to other metals in the same manner; and that iron, platinum and other metals may be welded together well below their fusing temperature. This welding action is aided by the formation of the intermetallic compounds. By analogy with other active metals, zinc will unite with iron, copper, nickel and other metals below its melting point because of the affinity of the metals involved as shown by the intermetallic compounds formed.

The iron in the sherardized coating has an important effect on its *weathering properties*. The writer has found that coatings containing high percentages of iron withstand weathering poorly. The amount of iron in the zinc dust used is also important. If the zinc dust used is high in iron, 2 to 4 per cent, the dust clinging to the coating will turn red when it becomes moist. The writer has found that some manufacturers were unable to turn out as good a coating at the end of the year as when they first installed the process. When the process was new the metallic content of the zinc dust was high, while the iron content was negligible. As the zinc dust was used the metallic content dropped and the iron content of the dust increased due to various causes. The temperature required for sherardizing had to be increased, and as a result the coating became less resistant to weathering.

To obtain the best possible results in service corrosion tests, the sherardizing process has been studied in detail at the General Electric Company. By studying the process in detail the practice was standardized. It was found that in order to secure complete control of the process it was necessary to have complete temperature control and an unvarying quality of zinc dust. Electric heating was found to give the best results.

The zinc dust used consists principally of the so-called "sherardizing zinc," a granulated zinc with an addition of a small proportion of "blue dust" or oxide. It contains from 80 to 92 per cent of metallic zinc. It would be impossible to run "blue dust" with this high metallic content due to its caking. With such a high metallic content the temperature regulation has to be close. The temperature used is about 365 deg. cent.

From time to time the zinc dust is run through a magnetic separator which prevents an undesirable accumulation of iron. A study of their data on sherardizing shows that the specific gravity of the coat, under a certain set of conditions, varies from 1 at 35 per cent of metallic zinc in the dust to 6.75 at 80 per cent. This shows that the coatings obtained under the usual sherardizing conditions are more or less porous, or contain occluded oxides, etc. The specific gravity has a decided influence on the resistance of the coating to corrosion. By means of the salt spray test it was found that only a coating with a density of at least 6.75 would stand up satisfactorily. This means that, if the sherardizing is done with a dust containing less than 80 per cent, the salt water spray test will be unsatisfactory, due to the porosity of the coating.

The article discusses further corrosion tests on sherardizing, removal of zinc dust from coated articles, zinc dust control, and the testing of sherardizing. Of practical importance are the following conclusions arrived at by the author: Sherardizing when carried out properly gives a coating that is highly resistant to corrosion. Sherardizing should be carried out at the lowest temperature economically possible to secure a low iron content in the coating. A zinc dust having a high metallic content will give the best coating. The copper sulphate test gives good results for daily furnace control tests. (*Metallurgical and Chemical Engineering*, vol. 14, no. 12, p. 683, June 15, 1916, 9 pp. *pteA*.)

Hobbing High Prime-Number Spur-Gears Without Special Mechanism, Will. O. Wynne

The usual clause in almost any description of a modern gear-hobbing machine is "with the exception of prime

numbers." The author describes a method of construction of a machine for hobbing any number of teeth up to 1000. The method is based on the following consideration: Although the prime number cannot be factorized it can be separated into two numbers one of which is less than 10 and the other divisible by 10, the sum of the two forming the prime number. While nothing in the nature of a dividing plate can be adopted in the hobbing machine, the addition and subtraction of continuous motions are easily dealt with by a differential gear and this is what is used in the first place to enable one to cope with the prime-number problem. It is well to remember that although high prime number spur gears may not be in general demand, the introduction of reduction gearing for turbines has rendered the production of high prime-number helical gears almost imperative in order to avoid synchronism and to distribute wear.

The author shows the application of his method to a gear hobbing machine with and without a differential gear, and shows that high prime-number spur gears can be produced on an ordinary gear-hobbing machine without special gearing.

Among the methods of handling this problem the following is of interest because of its comparative simplicity: Any prime number up to 1000 is within 5 of a number which will factorize into factors less than 100; therefore if the driving gear

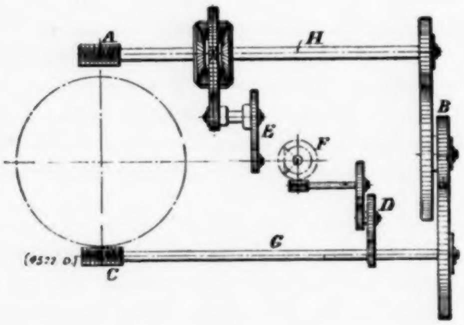


Fig. 5 Hobbing Machine with a Differential Gear in the Hob Drive

can be arranged so as to cut within 5 of the required number and the differential gear used to put on or take off up to 5 revolutions per revolution of the work, then any number up to 1000 can be dealt with.

In Fig. 5, where the worm drives the table through feed gears, E are the spiralling gears leading to the differential gears and so to A. There is no reason whatever why the gears E cannot be arranged of ratios which will impart 1, 2, 3, 4, or 5 additional revolutions to A, or take away that number of revolutions from A for one revolution of the table, altogether independent of the dividing gears B. Assume that it is necessary to cut 617 teeth. The dividing gears are then arranged to cut 620 teeth and by means of the differential gear three revolutions are taken off from the hob per revolution of the table. The spiral lead does not now come into the question at all.

$$\text{Ratio of change gears} = \frac{60}{620} = \frac{24}{80} \times \frac{20}{62}$$

$$\text{Feed gears to screw} = \frac{20}{50} \times \frac{15}{60}$$

Assume equal wheels at E. Let table make one revolution, then revolutions at A with dividing gears B and shaft H stationary =

$$1 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{2}{1} = 0.8 \text{ revolution}$$

Thus equal wheels at E will impart 0.8 additional revolution to A per revolution of table. But it is necessary to subtract 3 revolutions. Therefore, an adverse purchase of gears at E of $3 \div 0.8 = 90 \div 24$ must be introduced, taking care that the direction of rotation of the differential gear is such as will subtract from the motion of H, controlled, if necessary, by an intermediate at E.

$$\text{Dividing gears} = \frac{24}{62} \times \frac{20}{80}\text{; spiralling gears adverse} = \frac{90}{24}.$$

Again, let the table make 20 revolutions.

$$\text{Rev. of } H = 20 \times \frac{60}{1} \times \frac{80}{24} \times \frac{62}{20} = 12{,}400.$$

Revolutions subtracted from H by differential gear in 20 revolutions of table =

$$20 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{90}{24} \times \frac{2}{1} = 60$$

Total revolutions of A = 12,400 — 60 = 12,340. Number of

$$\text{revolutions of hob per revolution of work} = \frac{12340}{20} = 617.$$

It must be pointed out that with the method used the feed enters into the calculations, because, although in itself it bears no important relation to the motions which are operating to produce the spur gears, the gears which lead up to the feed screw form part of the train which is either taking off the spiral from the prime-number gear (in a method described in the article), or, in the method shown above, takes from the hob three revolutions during the one revolution of the table.

An interesting fact is that in the arrangement described which can cut any number up to 1000, less gearing actually is necessary than on a machine arranged to produce the usual limited range. (*Engineering*, vol. 101, no. 2634, p. 591, June 23, 1916, 2 pp., 4 figs. *d.*)

Oil versus Water for Quenching Forgings, C. D. Young.

Data of an investigation made to show the difference between the physical properties of a large forging quenched in water and those of a smaller forging quenched in oil.

The results obtained indicate that there is an advantage in the use of water as a quenching medium, providing proper care is taken in the handling of the steel throughout the process.

The forgings used for this experiment consisted of two 10-in. locomotive driving axles having a center bore 2 in. in diameter extending the entire length. Both axles were from the same melt of steel, and preliminary chemical analysis indicated the same chemical composition. Results of tension tests in which comparison is made with respect to the distance of the test specimens from the axis of the axle, and with respect to the location of the test specimens along the length of the axle, show that the average results are more nearly uniform in the latter case than in the former. This may be due to segregation, as it was found by chemical analysis that the carbon content was not uniform throughout the section. This leads the author to recommend that in all specifications for forgings which are to be heat-treated there be included a

clause to govern the allowable amount of segregation; otherwise it may be expected that extreme segregation will be found, as in the case of the specimens described in the article. (*The Iron Age*, vol. 97, no. 26, p. 1546, June 29, 1916, 2 pp., *eA*.)

Mechanics

THE DYNAMIC BALANCE OF MACHINES, Chas. L. Clarke

The article is in the form of a statement from the consulting engineering department of the General Electric Company, and gives a brief exposition of the fundamental principles of mechanics as related to the phenomena of dynamic balance, as well as the reasons why the question of dynamic balance is becoming more and more important. The writer points out that on top of the refinement in balancing necessary for engineering reasons comes a growing insistence on a condition of reasonable quietude in relation to the operation of machines, which may be expressed as proceeding from a condition of nerves—people are getting more "touchy"; their perceptive faculties for noise and vibration are more acute and more easily upset than formerly; there is jolt and jar and clangor enough without adding to it when avoidable, and with the rapidly increasing use of machines in the home and business places, no noise or vibration of distracting amounts should enter with them, while in the factory where line shafting and belts have been supplanted by motors, the continuous purr of the former must not be replaced by an annoying high-pitch tremble or deep rumble coming from ill-balanced motors. Other things being equal the quiet machine will get the market.

The following is given as practical advice:

When a machine is apparently badly out of balance do not be in haste to condemn it. Look into the conditions of its use and see whether they may not reasonably be so modified as to cause the apparently undue out-of-balance to disappear else it may prove to be largely oneself, from the all-around technical and also commercial point of view, that is in reality out of balance. (*General Electric Review*, vol. 19, no. 7, p. 649, July, 1916, 3 pp. *g*.)

THE CRITICAL SPEEDS OF SHAFTS, W. M. Wallace

Discussion of the whirling speed of shafts, based not on mathematical methods of investigation but on data obtained from actual tests.

The writer objects to an exclusively mathematical method of reasoning. He states that in actual tests he noticed that, for shafts loaded as is usual in actual machines, the whirling frequency was never far removed from the vibration frequency of the shaft when not rotating. The slight difference between the two is due to the gyroscopic action of the masses forming the load on the shaft. This action tends to increase the frequency at whirling. In practice it is usually very difficult to detect this difference, partly because it is very small, but chiefly because other factors such as the effect of the length and play of the bearings are of far greater importance. In the usual mathematical treatment it is this gyroscopic action which looms large while the bearings and other effects are neglected.

If the attached masses are sufficiently eccentric to produce an appreciable whirl when on the critical speed, then the shaft whirls through a range of speeds, and it is not easy to detect exactly when the whirling commences or ends. In fact in practice with actual materials all sorts of things happen. Some shafts do not whirl at all, but have two distinct critical speeds not far removed from each other and on each of which the shaft vibrates transversely. In one case a horizontal loaded shaft freely supported at its ends was driven by a horizontal belt on a pulley mounted in the shaft between the two supports and at a short distance from one support. To limit the deflection of the shaft when at the critical speed, a cast-iron ring encircling the middle of the shaft was firmly attached to a stand. On speeding up a speed was reached at which the shaft commenced to hammer the ring in a vertical direction. At a slightly higher speed this hammering ceased and the shaft ran steadily through a short range of speeds, until it commenced hammering again, but this time in a horizontal direction. At higher speeds the shaft ran quite steadily. If by a whirl is meant the motion of the center of the section in an approximately circular path then that shaft did not whirl. It is not necessarily true either that the true critical speed for a shaft is at the arithmetical mean of the speeds at which whirling commences and ceases respectively. This serves to throw some light on the fact that the critical speed of a motor or turbine when speeding up differs slightly from that observed when running down.

The distortion of the true whirl may be also caused by variations in the elastic qualities of the material of the shaft for bending in different planes, but this is very rarely uniform for a rod or turned shaft.

The author derives his expressions for the critical speed by introducing a term indicating the stiffness of the shaft, which is done through the use of an expression for strain energy

FIG. 6 VIBRATIONS OF A MASSLESS CANTILEVER

in the shaft in terms of the deflection of the shaft under static loading.

Consider a massless cantilever EA, Fig. 6, with the load W at one end supported horizontally by a prop under the load. On suddenly removing the prop, the load falls through a distance y to its statical position of rest C, where it has acquired a velocity v such that $Wv^2 \div 2g = Wy \div 2$. Although the load loses potential energy Wy in falling from A to C, half of this is stored as strain energy in the cantilever. Continuing its downward journey, it comes to rest at B where $CB = CA$. Now v is the velocity of a point in the equivalent circular path of radius y and is, therefore, equal to $2\pi y \div T$ where T is the periodic time. Hence:

$$\frac{Wy}{2} = \frac{4\pi^2 y^2}{2g\,T^2}, \text{ or } T = \sqrt{\frac{Wy^2}{g\,Wy}}$$

With the number of masses on the cantilever at different points, since the sum of the potential energies in the extreme position is equal to the sum of the kinetic energies in mid-position, we must have

$$T = \sqrt{\frac{\Sigma Wy^2}{g \Sigma\, Wy}}$$

All this would apply to a shaft supported at the ends or in any other manner, and since in most cases the whirling time is practically equal to the time of vibration this gives a simple rule for expressing it. The critical or whirling speed is then expressed in revolutions per minute by

$$N = \frac{30}{\pi}\sqrt{\frac{g\,\Sigma\, Wy}{\Sigma\, Wy^2}}$$

the quantity y in the terms $\Sigma\ Wy^2$ and $g\ \Sigma\ Wy$ is the deflection of the shaft at the point at which any load W is applied when statically loaded by the particular systems of load.

The gyroscopic action of the masses attached to the shaft may induce a stiffening couple on the shaft and thereby increase the frequency at which whirling commences. In most cases it is insignificant. In fact the writer's experience shows that in practice so many factors operate to lower the frequency that one welcomes a slight tendency in the opposite direction to balance matters a little. However, if the attached masses have large radii of gyration R about the axis perpendicular to the shaft, and are so situated that a considerable amount of angular momentum is imparted to them when the shaft vibrates, the more correct expression for the whirling frequency is

$$N = \frac{30}{\pi}\sqrt{\frac{g\ \Sigma\ Wy}{\Sigma\ Wy^2 - \Sigma\ Wk^2\ \theta^2}}$$

where θ is the angle that the deflected shaft makes with the line of centers at the point of application of the load. In actual practice it is unnecessary to estimate the gyroscopic term, since, as the author shows, it affects actual results by only a fraction of one per cent.

The large difference between the actual and the theoretical whirling frequencies is due in the writer's opinion to an inaccurate estimate of the length of the vibrating shaft. This is an extremely important factor as the frequency varies as $L^{3/2}$. When a shaft is supported at the two ends only the length should be taken to the extreme outer ends of the bearings for the usual clearances allow of an appreciable deflection of the shaft at the middle of the bearings. (*The Engineer*, vol. 121, no. 3155, p. 495, June 16, 1916, serial article, not finished.)

Power Generation

Diesel Engines vs. Steam Turbines for Mine Power Plants, Herbert Haas

Cheap power is essential to large-scale mining and metallurgical operations, particularly where fine grinding of large tonnages has to be resorted to as is the case with an increasing number of mines treating disseminated copper ores or low grade gold ores. As many of our most important mines are located in sections where neither cheap coal nor water power is available, and the price of oil fuel is increased by long hauls, the Diesel engine will become a prime mover of increasing importance, especially in the Southwestern States where an ample supply of cold water for condensing purposes is unusual and local climatic conditions interfere in securing the high vacua essential to high turbine efficiency.

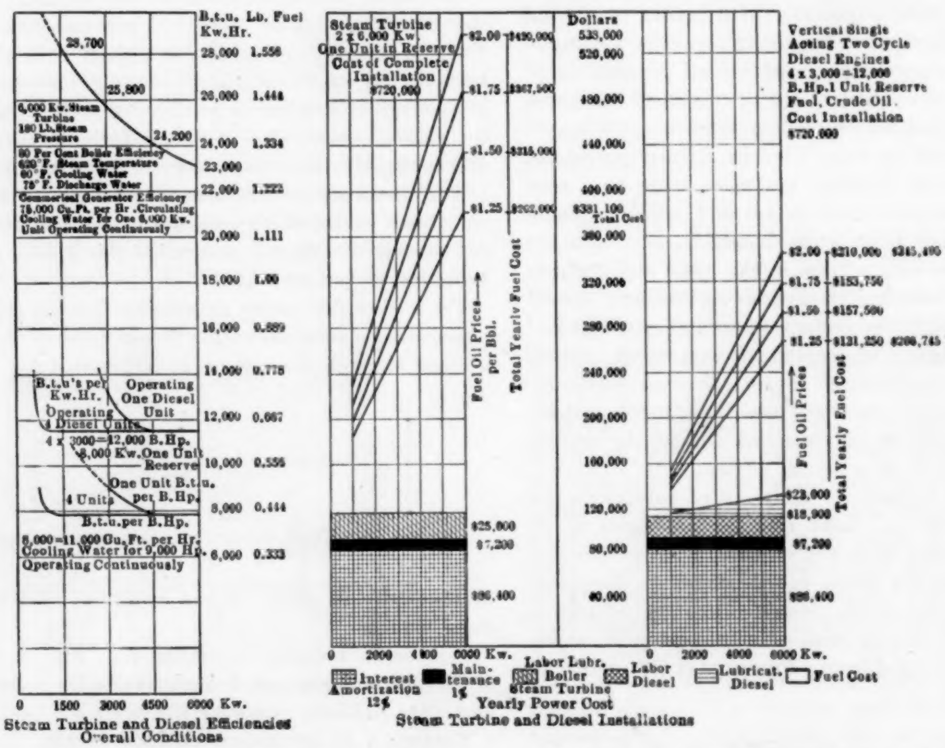


Fig. 7 Comparison of Steam Engine and Diesel Engine Efficiencies and Costs

About twelve times as much water will be required for condensing purposes with steam turbines under general conditions as is needed for jacket-cooling of 2-stroke cycle Diesel engines; 4-stroke cycle Diesel engines require only 1/20 of the cooling water.

Another condition favoring the use of Diesel engines is the high load factor at which most mine power plants operate. The influence of load factor on the cost of generating power is shown in Fig. 7.

The author compares the cost of the power with, on one hand, four 3000 b.h.p. Sulzer Diesel engines direct-connected to alternators and exciters, and on the other hand with two 6000 kw. steam turbines. (The author gives the reasons favoring the selection for purposes of comparison of two 6000 kw. steam turbines and four 3000 kw. Diesel engine generating sets.) The results the author finds are that, with outputs of 70,000,000, 52,500,000, 35,000,000 and 17,500,000 kw.-hr. per

year respectively, a kw.-hr. will cost from 1.0257 for the highest output to 1.6291 cents for the lowest output with steam turbines, and from 0.6045 to 1.0856 cents with Diesel engines.

In general the selection of either type of prime mover will be governed by the following economic conditions:

(1) Fuel is of chief influence on the total cost where both B.t.u. price and load factor are high. By B.t.u. price is here meant the cost for a given number of B.t.u, say 1,000,000, all fuel prices being reduced to this standard of comparison.

(2) Interest and redemption are of chief influence on the total power cost with low B.t.u. price and low load factor.

(3) Steam power will remain the cheapest power wherever waste heat gases are available, as for instance gases from reverberatory smelting furnaces.

(4) Up to capacities of 1000 h.p., steam turbines can compete with Diesel engines only in special cases, such as supplying exhaust steam for heating purposes. For such small units, particularly for greatly varying loads, high-grade reciprocating steam engines are preferable.

In comparing prices of different kinds of fuel such as gas, coal or liquid fuels, it is well to reduce all fuel prices to a common basis of absolute cost for 1,000,000 B.t.u. This, together with the knowledge of the thermal efficiencies of different prime movers, will enable one to arrive at the absolute fuel cost of each per brake horse-power-hour with different kinds of fuel. When a supply of liquid fuel is available, the sound economic application of steam turbines and Diesel engines is determined by fuel prices and load factor. The author gives a diagram (Fig. 8) showing at a glance whether a steam turbine or a Diesel engine power plant is in place with the given fuel price and load factor. The power costs represented by the curves include capacity costs and fuel costs but not operating labor. The latter is about the same for either type of plant, except for very large steam turbine plants which require less operating labor than Diesel engines. The curves marked *quarter load* cover fuel costs for ¼ kw.-yr., or 2,190 kw.-hr., and the same capacity charges as for full load; to arrive at the cost per kw.-yr. (8,760 kw.-hr.) at quarter load, the amount shown in dollars must be multiplied by 4.

The curves for steam turbine plants are based on 12 and 16 per cent efficiency (overall of the entire power plant); the higher figure is secured only with large units in sizes from 10,000 kw. upward.

The cost for lubrication is considerably higher for Diesel plants than for turbine plants, and amounts to from $2.00 to $4.00 per kw-yr., depending on the type of lubricating system used and the care of oilers. In turbine plants this greater expense for Diesel engines is partly balanced by the large amount of water required for condensing, which is 12 to 20 times greater than the supply needed for cooling Diesel engines. Only in plants with units in excess of 6000 kw. have turbines decided advantages over Diesel engine plants. (*Bulletin of the American Institution of Mining Engineers*, no. 115, p. 1171, July 1916, 13 pp., 6 figs. *cp.*)

Railway Engineering

Santa Fe Type Locomotives for the Erie Railroad

Description of two of the most recently developed types of heavy non-articulated locomotives, in each of which, though they are designed for the same service, certain important deviations have been incorporated. An important detail of one of these designs is the provision for lateral motion in the driving wheels, a feature of design not heretofore attempted and put into practice in the so-called "rigid wheel base" locomotive.

The application of lateral motion driving axles and boxes to these locomotives was made for the purpose of reducing the rigid wheel base to that which is in common use on locomotives of smaller capacity, and at the same time securing the advantages of the 10-coupled wheel arrangement with the resulting increased capacity of the locomotive. The driving and rigid wheel-base dimensions of these engines are, respectively, 22 ft. 6 in. and 16 ft, 6 in., well within the figures used on a very large number of Mikado and consolidation locomotives.

The lateral box arrangement consists of two independent

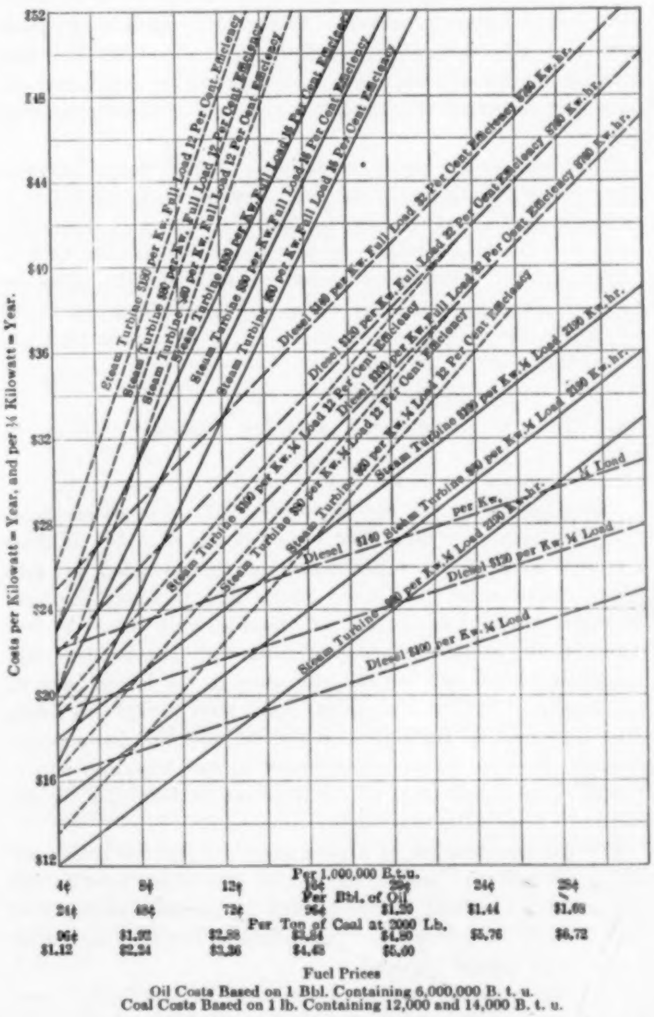


Fig. 8 Diagram Showing Comparative Costs of Steam Turbine and Diesel Engine Plants at Given Fuel Price and Load Factor

driving boxes, whose transverse lateral centers are about on a line with the inside of the main engine frames. When the boxes are deflected by a side movement of the first pair of driving wheels from their normal central position, they and the bridge casting move laterally in reference to the member carrying the springs. This movement deflects the inverted rockers, which offer a definite resistance against the motion. The spring and equalizer work, however, is not shifted from its normal position when the boxes are deflected laterally.

The operation of the lateral motion axle should be considered in connection with the engine truck which is, on this engine, of the inverted rocker type having a resistance of 50

per cent against the initial movement, while the resistance of the lateral device at the first driver is 20 per cent. These resistances are so chosen in relation to the weight coming upon each centering device, that the lateral resultants at the engine truck and the first driver are about the same in amount.

The resistance of the lateral motion box is proportioned with the idea of providing enough initial resistance so that, for any ordinary road service on tangent track or road curves, the first driver will remain in normal position and deflect only when passing through turn-outs and yard curves. The action of the rockers provides a limit to the lateral pressure which can be placed upon the first driving wheel flange, the excess lateral pressure being transferred by the deflection of the boxes to the second pair of drivers. This divides the work of guiding the engine through curves between the truck and the first and the second drivers, instead of between the truck and the first pair of drivers only as in the ordinary 10-coupled locomotive.

The same article describes Baldwin 2-10-2 Santa Fe locomotives for the Erie railroad, with straight boiler 96.25 in. in diameter and a superheating surface of 1389 sq. ft., the latter composed of 48 elements. In this design the Gaines arch is replaced by a combustion chamber which has the effect of increasing the plate heating surface of the fire-box end by 63 sq. ft. (*Railway Review*, vol. 58, no. 24, p. 817, June 10, 1916, 6 pp., 9 figs. *d.*)

THE MODERN SUPERHEATER AND ITS PERFORMANCE, S. S. Riegel

The paper describes the application of superheaters especially to locomotive use. The writer points out that as there are now over 16,000 superheaters of the so-called fire-tube type in service in the United States and Canada, this may be called standard equipment on American railroads. At first considerable trouble was experienced with the headers and cracks developed between the unit seats in the lower faces of the headers. This was overcome by a later design providing free movement of the several parts, the so-called loose finger design. Another recent improvement in the American superheater is the substitution of a welded return bend for the old cast-steel form known as the torpedo end.

For the maintenance of a permanently tight connection between the unit and header, the header bolts must have a high elastic limit of about 70,000 lb. and an ultimate strength of over 100,000 lb. per sq. in. This problem has been solved by the use of a special material.

The conversion of existing locomotives to superheater locomotives is discussed mainly from an economic standpoint. In general, the modernizing of existing engines by the application of superheaters has permitted the railroads to keep pace with increased demands, as the change from wood to steel equipment, heavier rails, more exact service, etc. During the year 1915, out of 3667 superheaters applied in the United States and Canada more than 2000 were used on old engines, and as a matter of fact locomotives are today superheated which would not have been considered three years ago. A comparatively recent development is the superheating of switch engines.

As to lubrication, the writer states that it is not sufficient to have lubricators which work uniformly, but drifting steam must be used under automatic control. Results without drifting steam are usually unsatisfactory. The superheater in the present form is very sensitive, but with proper handling and maintenance is giving very satisfactory results. The author advises the use of some instrument like the pyrometer for the proper determination of the amount of superheat in the steam when more reliable records are required.

He concludes by questioning whether the type of superheater so universally used is one which will endure, or if it is to be superseded by a more durable and more efficient type. (*Central Railway Club*, vol. 24, no. 3, p. 137, May Meeting, 1916, 8 pp. *g.*)

EQUALIZATION OF LONG LOCOMOTIVES

Discussion of the subject of the equalization of long locomotives presented as a report of a committee of which William Elmer, Mem.Am.Soc.M.E., was chairman, before the convention of the American Railway Master Mechanics' Association at Atlantic City, June 20, 1916. The report gives a brief review of early locomotive invention, and then proceeds to develop formulae from which to devise systems of equalization for locomotives of the less complicated types now in use.

The methods followed in working out the actual equalization of the various classes of locomotives depend on the type. The simplest form of wheel base is 0-4-0 or four-wheel switcher. In order to allow the wheels to follow the irregularities in the track without materially changing the loads on the journals, it is necessary to adopt the so-called three-legged stool principle. This involves designing the spring rigging so that the engine frames and all parts attached to them shall be carried on the fundamental points of support commonly called the three point suspension. The author derives formulae for the loads carried by each of the springs at their supports.

The author next discusses locomotives of the 0-6-0 type having six driving wheels and no truck and derives formulae for this case. In the eight and ten driving wheel locomotives with no truck, the spring hangers have to be anchored to the frames between the drivers between which the center of gravity of the spring-borne parts comes. If this point is overlooked there will be danger of some of the wheels not carrying enough weight in case the springs or spring hangers are not properly made and a derailment may occur. He discusses next locomotives of the Mogul, consolidation, decapod and American types, and derives the proper formulae as to loads on supports for each one of these types. From these formulae the weight distribution of any properly designed locomotive can be accurately determined. The writer points out that there are locomotives in service in this country in which the spring rigging has not been properly designed, and these locomotives require constant attention to see that the different axles carry the proper weight. (*Railway Review*, vol. 59, no. 1, p. 12. July 1, 1916, 4 pp. *tm.*)

DRAFT GEAR COMMITTEE'S TESTS ON DRAFT CHANNELS

Abstract of the report of the Draft Gear Committee presented at this year's convention of the Master Car Builders' Association, reporting data of tests made to determine the maximum end force that could be put on the end frames of freight cars without overstraining them. The tests were made at the laboratory of the Union Draft Gear Company, equipped with a 15,000-lb. pendulum hammer so arranged that it can be raised to any desired height and allowed to drop against a 30,000-lb. car that runs on a straight level track.

The method of testing was to mount some form of draft gear and place the car so that the top of the hammer stood against the improvised coupler shank with the pendulum ham-

mer at its lowest point. The hammer was then raised to a desired height by means of a large electric magnet, and the recording drum started with the pencil in contact with the paper. The hammer was dropped and in this way any movement of the car was recorded on the paper, these records being checked by a 10 in. Berry strain gage.

Seven sets of chapnels were tested, five ordinary and two heavy sets, all 12 in. deep; the five had a weight of 25 lb. per ft. and the two heavy ones a weight of 40 lb. per ft.

The data are presented in the form of tables and curves. It was found that the maximum end force on the 25-lb. channels is approximately 600,000 lb. but that a force of approximately 450,000 lb. will cause the channel to be overstrained. On the heavier channels the maximum of the channel capacity was not reached because the lugs sheared at about 850,000 lb. The overstrained point on the heavier channel was found, however, as lying probably a little over 700,000 lb. It was further found that if a draft gear in a car goes solid before all the energy is absorbed or transmitted to the next car, the pressure is transmitted to the underframe immediately. It took only about 5000 ft-lb. of energy to do it in this case.

It is the opinion of the Draft Gear Committee that a draft gear is needed that will absorb enough of the energy to keep the pressure down below the elastic limit of the sills. The Committee calls attention to the fact that ten rivets were sheared off in two of the tests and that a longer lug with more rivets in it should be provided by the Association in the M. C. B. lug.

(As the *Railway Review* points out in an editorial [June 24, p. 921] a very great saving can be made by using a draft gear of greater ability to do the work rather than increasing the weight and strength of the car end frames so that both the lading and superstructure have to suffer. (*Railway Review*, vol. 58, no. 25, p. 864, June 17, 1916, 4 pp., 6 figs. *eA*).

Steam Engineering

EFFICIENCIES OF STEAM PRIME MOVERS, Prof. F. O. Ellenwood, Mem.Am.Soc.M.E.

The writer discusses various conceptions of efficiency of steam prime movers, giving in every case attempted definitions of the terms and side by side equivalent terms used in engineering literature, with references to published works where these terms are so used.

The article covers the subjects of the Carnot efficiency, efficiency of the Rankine cycle, and also the Indicated Thermal Efficiency, Brake Thermal Efficiency and Combined Thermal Efficiency, with their equivalents. The discussion comprises also the various efficiency ratios, such as Indicated Efficiency Ratio, Brake Efficiency Ratio and Combined Efficiency Ratio. Fig. 9 gives a bird's-eye view of the terms suggested by the author and their relation to one another. It also serves to show how the three words, *indicated, brake,* and *combined,* when applied to the two bases, *thermal efficiency* and *efficiency ratio,* give, without any tax on the memory, a definite and concise expression for each of the six important efficiencies commonly required in engineering practice. The author considers it unnecessary to introduce a term for expressing the relation between the net work of the Rankine cycle and the net work of the Carnot cycle for the same temperature limits (various writers have used for it such terms as *relative efficiency* and *type efficiency*). At the end of the article a brief bibliography is given. (*The Sibley Journal of Engineering, Cornell University*, vol. 30, no. 9, p. 288, June 1916, 6 pp., 1 fig. *tc*).

SOME ERRORS IN STEAM TABLES

Some very elaborate and convenient steam tables issued of late years have as their basis certain experimental work carried out in Germany. To the belief of the writer, the compilers appear to have adopted the results of these experiments without sufficient criticism of the methods employed, with the result that their tabulated values of total heats and specific volumes of steam are mutually inconsistent.

The author sees this inconsistency in the following: When steam is expanded adiabatically, the work done can be estimated in two ways. It is equal to the area of the indicator diagram $\left(\frac{144}{J}\int V dp\right)$, and also to the difference between the total heats of the steam in its initial and final conditions. Hence if the tables are correct the two should equal each other, but as a matter of fact this does not hold if the quantities involved be abstracted from tables based upon the experimental work referred to, as the author shows in examples. He comes to the conclusion that the absolute values of the total heat tabulated are probably materially in error. The author does not specifically mention the tables in which he found these errors. (*Engineering*, vol. 101, no. 2632, p. 545, June 9, 1916, 1 p. *g*.)

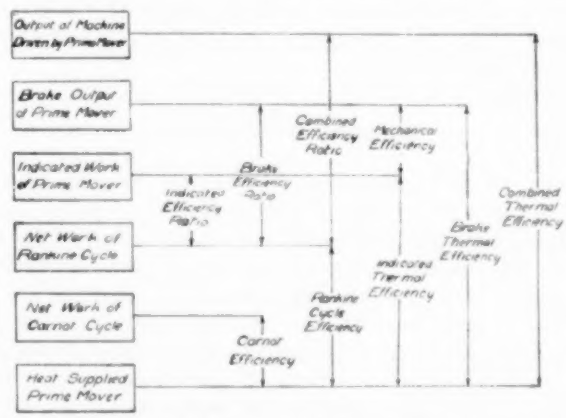


FIG. 9 DIAGRAM SHOWING THE RELATION OF THE EFFICIENCIES OF STEAM PRIME MOVERS

HIGH TURBINE ECONOMY AT POOR LOAD FACTORS

High turbine economies have usually been difficult to obtain in small stations operating at poor load factors, because a sufficient number of differently rated generators is not usually installed to permit the operation of such a combination that each machine will carry its full rate of load under all conditions. The introduction of double-nozzle gear-type steam turbines offers one solution to this problem by making it possible to operate these units at almost as high economy below rated load as at full load.

The article gives data of the operation of two small central stations, one at Dowagiac, Mich., and the other at Hoopeston, Ill.

The generating equipment at the Michigan station includes a two-nozzle Westinghouse turbine designed for 150 lb. pressure and 7400 r.p.m., geared 8 to 1 to a 150-kw. three-phase,

60-cycle, 1150-2300-volt, 900-r.p.m. belted-type generator. The turbine operates condensing. The 300-kw. Westinghouse units at Hoopeston are designed for 150 lb. throttle pressure and run 6000 r.p.m. non-condensing. The efficiency is practically the same at one-quarter and one-half load as it is at three-quarters and full load. The nozzles of the turbine at Dowagiac are set to carry equal loads, while in the Hoopeston plant they are set to carry one-third and two-thirds of the total respectively. Because of dissimilar requirements, different adjustments are used at these two plants. At Dowagiac the load is practically fixed. The steam pressure is maintained at 125 lb., which reduces the capacity of one nozzle from 75 kw. at 150 lb. to approximately 60 kw. so that the turbine may be operated with one nozzle at nearly full load, and at any time the capacity of the turbine when operating with one nozzle can be increased to 75 kw. by boosting the steam pressure without resetting the nozzle. This is particularly so as the economy is practically the same at 125 as at 150 lb. steam pressure. At Hoopeston the one-third, two-thirds setting makes it possible to operate the 300-kw. units at almost full-load economy on practically all loads.

The article gives the guaranteed steam consumptions in the form of a table and data on performances in the form of curves. (*Electrical World*, vol. 68, no. 2, p. 66, July 8, 1916, 3 pp., 7 figs. *d.*)

Unit No. 3 at the Northwestern Station, Thomas Wilson

Description of a compound turbine with its auxiliaries installed in the latter part of 1915 in the Northwestern station of the Commonwealth Edison Company of Chicago. The turbine of this machine, which has high and low pressure elements mounted in tandem on the same shaft but in separate casings, is rated at 45,000 h.p. Steam at 230 lb. pressure and 200 deg. fahr. superheat, or at a temperature approximating 600 deg. fahr., is supplied to the turbine. Within the steam chest there are 14 steam admission valves, all under the control of the governor and delivering steam to the upper half of the first stage. There are also four overload valves, each opening simultaneously with one of the last four admission valves. These valves through a series of nozzles discharge steam from the first into the fourth stage. Fig. 10 shows diagrammatically the steam and water piping. Circulating water for the condenser is drawn from the intake tunnel by a 48-in. double suction tri-rotor pump driven directly by a 650-h.p. Curtis non-condensing turbine at 1500 r.p.m. With the pump working at its rating and the condenser at its normal capacity, 72 lb. of water would be supplied per pound of steam. The tremendous size of the installation can be seen from the fact that in a day of 24 hours a total of 74,880,000 gal. of circulating water would be delivered.

Entering the condenser the steam comes in contact with the preheating feed-water tubes, giving up part of its heat before passing into the condensing space proper. The air and condensate are taken from the condenser through a single outlet by a turbo air pump on the same shaft as the circulating pump.

The condensate passes from the heater to the turbine-driven boiler feed pumps, of which there are two and which discharge to the economizers located above the boilers. (*Power*, vol. 43, no. 25, p. 866 June 20, 1916, 3 pp., 5 figs. *d.*)

Lucerne Mines Power Plant, Warren O. Rogers

Description of 12,000-kw. capacity steam turbine plant supplying electrical energy to a group of mines at the Lucerne Mines, Lucerne, Pa. The interest of the plant lies in the fact that bone fuel varying in heating value from 8500 to 12,000 B.t.u. and containing from 20 to 35 per cent of ash is used in the furnaces. The average water evaporated per pound of fuel is about 7½ lb.

The ashes from the furnace ash pits are wetted down and loaded directly into empty coal cars run into position for receiving them.

To burn the bone fuel successfully forced draft is necessary (about 150 tons of fuel are burned each 24 hours). The draft is supplied by two 11-ft. diameter, 5 ft. 3 in. wide semi-inclosed fans, each driven by a 13-in. x 16-in. horizontal engine at a maximum speed of 225 r.p.m. An air pressure of from 2 to 2½ in. of water is maintained.

There are two 3000-kw. turbines of an older design and one

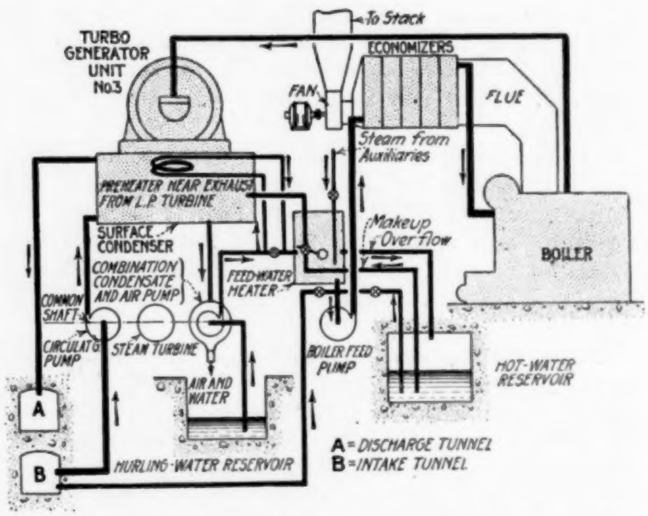


Fig. 10 Diagrammatic Sketch of Steam and Water Piping of the 45,000-h.p. Turbine Installation at the Northwestern Station, Chicago

6000-kw. unit new. Significantly, the new unit having a capacity equal to the other two machines occupies practically the same floor space, and when running with a 5000-kw. load will save the steam that can be generated by one of the 500-h.p. boilers over what would be consumed if the same load were being carried by the two smaller units. (*Power*, vol. 44, no. 2, p. 42, July 11, 1916, 4 pp., 4 figs. *d.*)

Steam Power Plants for Aeroplanes, Robert Cramer, Mem.Am.Soc.M.E.

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Operating pressures in the Winslow boiler have been frequently carried to 600 lb. per sq. in., and in special cases as high as 1500 lb. (*Journal of the Aeronautical Society of America*, vol. 1, no. 3-4, p. 28, March-April 1916, 4 pp., 4 figs. *d.*)

Classification: *c*, comparative; *d*, descriptive; *e*, experimental; *g*, general; *h*, historical; *m*, mathematical; *p*, practical; *s*, statistical; *t*, theoretical; *A*, special merit.

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